ABC - Stands for Artificial Bee Colony

AN IDEA BASED ON HONEY BEE SWARM FOR NUMERICAL OPTIMIZATION

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A powerful and efficient algorithm for numerical function optimization: artificial bee colony (ABC) algorithm

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The movement of the bees is recorded in three phases

Employed Phase-

- Generate a new solution.
- Calculate new fitness.
- Apply greedy selection.

Onlooker Phase-

- Calculate the probabilities.
- Produce a new solution depending on probability.
- Calculate new fitness.
- Apply greedy selection.

Scout Phase-

Find the abandoned solution (based on the value of *limit*)

- Generate a new solution randomly to replace them.

Working Rule (Algorithm)

Employed Phase

For each food source

Select update Variable & Partner

Update the variable with

$X_{new} = X + \phi(X - X_p)$, $\phi \in [-1,1]$;

Apply Greedy Selection

Calculate probabilities

Onlooker phase

Select the random number (r)

If r < prob.

Update the food sources based on random variable & probability

If trial counter > limit

Apply Scout Phase

Generate New Solution ramdomly

iter = iter + 1

Illustrative Example

Maximize $f(X) = x_1^2 - x_1 x_2 + x_2^2 + 2x_1 + 4x_2 + 3$

where $-5 \leq x_1, x_2 \leq 5$

ABC Parameter Setting (used only for illustration)

Randomly chosen:

Swarm (Population) Size = 10 (N); No. of cycle (Iteration) = 20

Dimension of the problem = 2 (D); Limit = 1 $\frac{N}{2} \times D$

No. of employed bees = no. of onlooker bees = food sources = 5

In ABC, our Goal is to calculate and update these values

food Source $f(x)$ fit trial

$$\begin{bmatrix} \cdots & \cdots \\ \cdots & \cdots \\ \cdots & \cdots \\ \cdots & \cdots \\ \cdots & \cdots \end{bmatrix}; \begin{bmatrix} \cdots \\ \cdots \\ \cdots \\ \cdots \\ \cdots \end{bmatrix}; \begin{bmatrix} \cdots \\ \cdots \\ \cdots \\ \cdots \\ \cdots \end{bmatrix}; \begin{bmatrix} \cdots \\ \cdots \\ \cdots \\ \cdots \\ \cdots \end{bmatrix}$$

$-5 \leq x_1, x_2 \leq 5$

Randomly Initialize food source between -5 & 5

Use $x = L + rand.*(U - L)$

	food Source		$f(x)$	fit	trial
F1	3.1472	−4.0246	...	...	...
F2	4.0579	−2.2150	...	...	...
	−3.7301	0.4688	...	...	...
	4.1338	4.5751	...	...	...
F5	1.3236	4.6489	...	...	...

Randomly Initialize food source between -5 & 5

Calculate function values f(x):

	food Source		Maximize $f(x)$	Minimize fit	trial
	x_1	x_2			
	3.1472	−4.0246	31.9645	...	...
	4.0579	−2.2150	32.6168	...	...
	−3.7301	0.4688	13.2971	...	...
	4.1338	4.5751	48.6753	...	...
	1.3236	4.6489	41.4537	...	...

Maximize $f(X) = x_1^2 - x_1 x_2 + x_2^2 + 2x_1 + 4x_2 + 3$

Randomly Initialize food source between -5 & 5

Calculate function values f(x):

Calculate the fitness:

	food Source		Maximize $f(x)$	Minimize fit	trial
	3.1472	−4.0246	31.9645	...	...
	4.0579	−2.2150	32.6168	...	...
	−3.7301	0.4688	13.2971	...	...
	4.1338	4.5751	48.6753	...	...
	1.3236	4.6489	41.4537	...	...

$$\text{fit} = \begin{cases} \frac{1}{1+f} & ; \quad f \geq 0 \\ 1 + |f| & ; \quad f < 0 \end{cases}$$

Randomly Initialize food source between -5 & 5

Calculate function values f(x):

Calculate the fitness :

$$\frac{1}{1 + 31.9645} = 0.0303$$

food Source		Maximize $f(x)$	Minimize fit	trial
3.1472	−4.0246	31.9645	0.0303	...
4.0579	−2.2150	32.6168	0.0297	...
−3.7301	0.4688	13.2971	0.0699	...
4.1338	4.5751	48.6753	0.0201	...
1.3236	4.6489	41.4537	0.0236	...

$$\text{fit} = \begin{cases} \frac{1}{1+f} \; ; & f \geq 0 \\ 1 + |f| \; ; & f < 0 \end{cases}$$

Randomly Initialize food source between -5 & 5

Calculate function values f(x):

Calculate the fitness :

Set the initial trial vector

food Source		Maximize $f(x)$	Minimize fit	trial
3.1472	−4.0246	31.9645	0.0303	0
4.0579	−2.2150	32.6168	0.0297	0
−3.7301	0.4688	13.2971	0.0699	0
4.1338	4.5751	48.6753	0.0201	0
1.3236	4.6489	41.4537	0.0236	0

Updation rule for Trial Counter

If solution

- Couldn't improve then we increase trail counter by 1.
- Improve, we reset to 0

Employed bee Phase:

1st employed bee: [3.1472 −4.0246]

	food Source		Maximize $f(x)$	Minimize fit	trial
	x_1	x_2			
F1	3.1472	−4.0246	31.9645	0.0303	0
F2	4.0579	−2.2150	32.6168	0.0297	0
F3	−3.7301	0.4688	13.2971	0.0699	0
F4	4.1338	4.5751	48.6753	0.0201	0
F5	1.3236	4.6489	41.4537	0.0236	0

food Source	Maximize $f(x)$	Minimize fit	trial
....	.....	.....	...
....	.....	.....	...
....	.....	.....	...
....	.....	.....	...
....	.....	.....	...

Employed bee Phase:

1st employed bee: [3.1472 −4.0246]

Select the random variable to change:

Let it be 1 : [3.1472 −4.0246]

Select the random partner

food Source	Maximize $f(x)$	Minimize fit	trial
3.1472 −4.0246	31.9645	0.0303	0
4.0579 −2.2150	32.6168	0.0297	0
−3.7301 0.4688	13.2971	0.0699	0
4.1338 4.5751	48.6753	0.0201	0
1.3236 4.6489	41.4537	0.0236	0

food Source	Maximize $f(x)$	Minimize fit	trial
....	.....	.....	...
....	.....	.....	...
....	.....	.....	...
....	.....	.....	...
....	.....	.....	...

Employed bee Phase:

1st employed bee: [3.1472 −4.0246]

Select the random variable to change:

Let it be 1 : [3.1472 −4.0246]

Select the random partner

Let partner be 4: [4.1338 4.5751]

food Source	Maximize $f(x)$	Minimize fit	trial
3.1472 −4.0246	31.9645	0.0303	0
4.0579 −2.2150	32.6168	0.0297	0
−3.7301 0.4688	13.2971	0.0699	0
4.1338 4.5751	48.6753	0.0201	0
1.3236 4.6489	41.4537	0.0236	0

food Source	Maximize $f(x)$	Minimize fit	trial
....	.....	.....	...
....	.....	.....	...
....	.....	.....	...
....	.....	.....	...
....	.....	.....	...

Employed bee Phase:

1st employed bee: [3.1472 −4.0246]

Select the random variable to change:

Let it be 1 : [3.1472 −4.0246]

Select the random partner

Let partner be 4: [4.1338 4.5751]

Create a new food location:

$$X_{new} = X + \phi(X - X_p)$$
$$\phi \in [-1,1];$$

food Source	Maximize $f(x)$	Minimize fit	trial
3.1472 −4.0246	31.9645	0.0303	0
4.0579 −2.1150	32.6168	0.0297	0
−3.7301 0.4688	13.2971	0.0699	0
4.1338 4.5751	48.6753	0.0201	0
1.3236 4.6489	41.4537	0.0236	0

food Source	Maximize $f(x)$	Minimize fit	trial
....	.....	.....	...
....	.....	.....	...
....	.....	.....	...
....	.....	.....	...
....	.....	.....	...

$-5 \le x_1, x_2 \le 5$

Employed bee Phase:

1st employed bee: [3.1472 −4.0246]

Select the random variable to change:

Let it be 1 : [3.1472 −4.0246]

Select the random partner

Let partner be 4: [4.1338 4.5751]

Create a new food location:

Let $\phi = 0.71$

$X_{new} = 3.1472 + 0.71(3.1472 - 4.1338)$

$= 2.4467 \in (-5,5)$

Thus, $X_1 = [2.4467 \quad -4.0246]$

$$X_{new} = X + \phi(X - X_p)$$
$$\phi \in [-1,1];$$

food Source	Maximize $f(x)$	Minimize fit	trial
3.1472 −4.0246	31.9645	0.0303	0
4.0579 −2.1150	32.6168	0.0297	0
−3.7301 0.4688	13.2971	0.0699	0
4.1338 4.5751	48.6753	0.0201	0
1.3236 4.6489	41.4537	0.0236	0

food Source	Maximize $f(x)$	Minimize fit	trial
....	.....	.....	...
....	.....	.....	...
....	.....	.....	...
....	.....	.....	...
....	.....	.....	...

Employed bee Phase:

1st employed bee: [3.1472 −4.0246]

Select the random variable to change:

Let it be 1 : [3.1472 −4.0246]

Select the random partner

Let partner be 4: [4.1338 4.5751]

Create a new food location:

Let $\phi = 0.71$

$X_{new} = 3.1472 + 0.71(3.1472 - 4.1338)$

$= 2.4467 \in (-5,5)$

Thus, $X_1 = [2.4467 \quad -4.0246]$

f(x) = 23.8259 ; fit = 0.0403

$$\frac{1}{1+f}; f \ge 0$$

food Source	Maximize $f(x)$	Minimize fit	trial
3.1472 −4.0246	31.9645	0.0303	0
4.0579 −2.1150	32.6168	0.0297	0
−3.7301 0.4688	13.2971	0.0699	0
4.1338 4.5751	48.6753	0.0201	0
1.3236 4.6489	41.4537	0.0236	0

food Source	Maximize $f(x)$	Minimize fit	trial
....	.....	.....	...
....	.....	.....	...
....	.....	.....	...
....	.....	.....	...
....	.....	.....	...

Employed bee Phase:

1st employed bee: [3.1472 −4.0246]

Select the random variable to change:

Let it be 1 : [3.1472 −4.0246]

Select the random partner

Let partner be 4: [4.1338 4.5751]

Create a new food location:

Let $\phi = 0.71$

$X_{new} = 3.1472 + 0.71(3.1472 - 4.1338)$

$= 2.4467 \in (-5,5)$

Thus, $X_1 = [2.4467 \quad -4.0246]$

f(x) = 23.8259 ; fit = 0.0403

Perform greedy selection:

Since 0.0303< 0.0403

so preserve the previous

food Source	Maximize $f(x)$	Minimize fit	trial
3.1472 −4.0246	31.9645	0.0303	0
4.0579 −2.1550	32.6168	0.0297	0
−3.7301 0.4688	13.2971	0.0699	0
4.1338 4.5751	48.6753	0.0201	0
1.3236 4.6489	41.4537	0.0236	0

food Source	Maximize $f(x)$	Minimize fit	trial
3.1472 −4.0246	31.9645	0.0303	1
....	.....	.....	..
....	.....	.....	..
....	.....	.....	..
....	.....	.....	..

Employed bee Phase:

1st employed bee: [3.1472 −4.0246]

Select the random variable to change:

Let it be 1 : [3.1472 −4.0246]

Select the random partner

Let partner be 4: [4.1338 4.5751]

Create a new food location:

Let $\phi = 0.71$

$X_{new} = 3.1472 + 0.71(3.1472 - 4.1338)$

$= 2.4467 \in (-5,5)$

Thus, $X_1 = [2.4467 \quad -4.0246]$

f(x) = 23.8259 ; fit = 0.0403

Perform greedy selection:

Since 0.0303< 0.0403

so preserve the previous

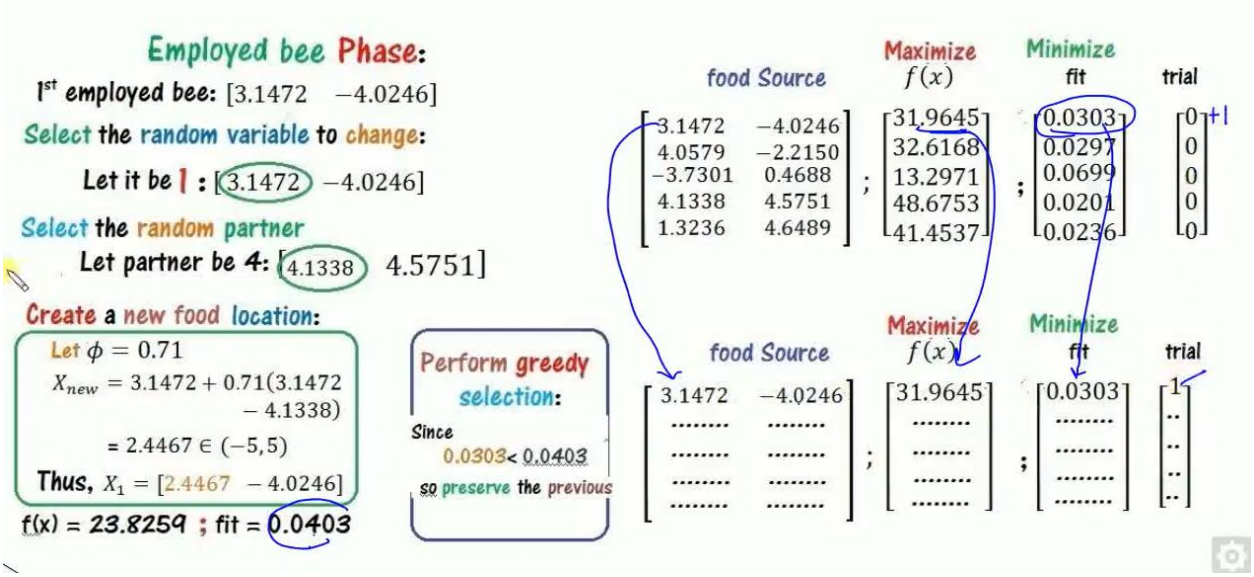
food Source	Maximize $f(x)$	Minimize fit	trial
3.1472 −4.0246	31.9645	0.0303	0
4.0579 −2.1550	32.6168	0.0297	0
−3.7301 0.4688	13.2971	0.0699	0
4.1338 4.5751	48.6753	0.0201	0
1.3236 4.6489	41.4537	0.0236	0

food Source	Maximize $f(x)$	Minimize fit	trial
3.1472 −4.0246	31.9645	0.0303	1
....	.....	.....	..
....	.....	.....	..
....	.....	.....	..
....	.....	.....	..

Updation rule for Trial Counter

If solution

- Couldn't improve then we increase trail counter by 1.
- Improve, we reset to 0


Employed bee Phase:
1st employed bee: [3.1472 −4.0246]
Select the random variable to change:
Let it be 1 : [3.1472 −4.0246]
Select the random partner
Let partner be 4: [4.1338 4.5751]
Create a new food location:
Let $\phi = 0.71$
$X_{new} = 3.1472 + 0.71(3.1472 - 4.1338)$
$= 2.4467 \in (-5,5)$
Thus, $X_1 = [2.4467 \quad -4.0246]$
f(x) = 23.8259 ; fit = 0.0403
Perform greedy selection:
Since
0.0303< 0.0403
so preserve the previous
food Source
Maximize $f(x)$
Minimize fit
trial
3.1472 −4.0246
4.0579 −2.2150
−3.7301 0.4688
4.1338 4.5751
1.3236 4.6489
31.9645
32.6168
13.2971
48.6753
41.4537
0.0303
0.0297
0.0699
0.0201
0.0236
0 +1
0
0
0
0
food Source
Maximize $f(x)$
Minimize fit
trial
3.1472 −4.0246
31.9645
0.0303
1

Employed bee Phase: 2nd employed bee:

Select the random variable to change: 2

Select the random partner: 3

Create a new food location: Let $\phi = 0.31$

$$X_{new} = -2.2150 + 0.31(-2.2150 - 0.4688)$$
$$= -3.0470 \in (-5, 5)$$

Thus, $X_2 = [4.0579 \quad -3.0470]$

Perform greedy selection:

Trial Value:

food Source	Maximize $f(x)$	Minimize fit	trial
3.1472 −4.0246	31.9645	0.0303	0
4.0579 −2.2150	32.6168	0.0297	0
−3.7301 0.4688	13.2971	0.0699	0
4.1338 4.5751	48.6753	0.0201	0
1.3236 4.6489	41.4537	0.0236	0

food Source	Maximize $f(x)$	Minimize fit	trial
3.1472 −4.0246	31.9645	0.0303	1
....	.....	.....	..
....	.....	.....	..
....	.....	.....	..
....	.....	.....	..

Employed bee Phase: 2nd employed bee:

Select the random variable to change: 2

Select the random partner: 3

Create a new food location: Let $\phi = 0.31$

$$X_{new} = -2.2150 + 0.31(-2.2150 - 0.4688)$$
$$= -3.0470 \in (-5, 5)$$

Thus, $X_2 = [4.0579 \quad -3.0470]$

f(x) = 37.0428 ; fit = 0.0263

Perform greedy selection:

As 0.0263< 0.0297 ; so update food source.

Trial Value:

food Source	Maximize $f(x)$	Minimize fit	trial
3.1472 −4.0246	31.9645	0.0303	0
4.0579 −2.2150	32.6168	0.0297	0
−3.7301 0.4688	13.2971	0.0699	0
4.1338 4.5751	48.6753	0.0201	0
1.3236 4.6489	41.4537	0.0236	0

food Source	Maximize $f(x)$	Minimize fit	trial
3.1472 −4.0246	31.9645	0.0303	1
4.0579 − 3.0470	37.0428	0.0263	..
....	.....	.....	..
....	.....	.....	..
....	.....	.....	..

Employed bee Phase: 2nd employed bee:

Select the random variable to change: 2

Select the random partner: 3

Create a new food location: Let $\phi = 0.31$

$$X_{new} = -2.2150 + 0.31(-2.2150 - 0.4688)$$
$$= -3.0470 \in (-5, 5)$$

Thus, $X_2 = [4.0579 \quad -3.0470]$

f(x) = 37.0428 ; fit = 0.0263

Perform greedy selection:

As 0.0263< 0.0297 ; so update food source.

Trial Value:

As there is an update, set trial(2) = 0

food Source	Maximize $f(x)$	Minimize fit	trial
3.1472 −4.0246	31.9645	0.0303	0
4.0579 −2.2150	32.6168	0.0297	0
−3.7301 0.4688	13.2971	0.0699	0
4.1338 4.5751	48.6753	0.0201	0
1.3236 4.6489	41.4537	0.0236	0

food Source	Maximize $f(x)$	Minimize fit	trial
3.1472 −4.0246	31.9645	0.0303	1
4.0579 − 3.0470	37.0428	0.0263	0
....	.....	.....	..
....	.....	.....	..
....	.....	.....	..

Employed bee Phase: 3rd employed bee:

Select the random variable to change: 2

Select the random partner: 1

Create a new food location: Let $\phi = 0.51$

$X_{new} = 2.7604 \in (-5, 5)$

Thus, $X_3 = [-3.7301 \quad 2.7604]$

f(x) = 38.4119 ; fit = 0.0254

Perform greedy selection:

As 0.0254 < 0.0699; so update X3.

Trial Value:

trial(3) = 0

food Source	Maximize $f(x)$	Minimize fit	trial
3.1472 −4.0246	31.9645	0.0303	0
4.0579 −2.2150	32.6168	0.0297	0
−3.7301 0.4688	13.2971	0.0699	0
4.1338 4.5751	48.6753	0.0201	0
1.3236 4.6489	41.4537	0.0236	0

food Source	Maximize $f(x)$	Minimize fit	trial
3.1472 −4.0246	31.9645	0.0303	1
4.0579 −3.0470	37.0428	0.0263	0
−3.7301 2.7604	38.4119	0.0254	0
....	.....	.....	..
....	.....	.....	..

Employed bee Phase: 4th employed bee:

Select the random variable to change: 1

Select the random partner: 2

Create a new food location: Let $\phi = -0.21$

$X_{new} = 4.1179 \in (-5, 5)$

Thus, $X_4 = [4.1179 \quad 4.5751]$

f(x) = 48.5848 ; fit = 0.0202

Perform greedy selection:

As 0.0201 < 0.0202; so no CHANGE.

Trial Value:

Set trial (4) = 1

food Source	Maximize $f(x)$	Minimize fit	trial
3.1472 −4.0246	31.9645	0.0303	0
4.0579 −2.2150	32.6168	0.0297	0
−3.7301 0.4688	13.2971	0.0699	0
4.1338 4.5751	48.6753	0.0201	0
1.3236 4.6489	41.4537	0.0236	0

food Source	Maximize $f(x)$	Minimize fit	trial
3.1472 −4.0246	31.9645	0.0303	1
4.0579 −3.0470	37.0428	0.0263	0
−3.7301 2.7604	38.4119	0.0254	0
4.1338 4.5751	48.6753	0.0201	1
....	.....	.....	..

Employed bee Phase: 5th employed bee:

Select the random variable to change: 1

Select the random partner: 4

Create a new food location: Let $\phi = -0.11$

$X_{new} = 1.6327 \in (-5, 5)$

Thus, $X_5 = [1.6327 \quad 4.6489]$

f(x) = 41.5487 ; fit = 0.0235

Perform greedy selection:

As 0.0235 < 0.0236; so update X5.

Trial Value:

Set trial(5) = 0

food Source	Maximize $f(x)$	Minimize fit	trial
3.1472 −4.0246	31.9645	0.0303	0
4.0579 −2.2150	32.6168	0.0297	0
−3.7301 0.4688	13.2971	0.0699	0
4.1338 4.5751	48.6753	0.0201	0
1.3236 4.6489	41.4537	0.0236	0

food Source	Maximize $f(x)$	Minimize fit	trial
3.1472 −4.0246	31.9645	0.0303	1
4.0579 −3.0470	37.0428	0.0263	0
−3.7301 2.7604	38.4119	0.0254	0
4.1338 4.5751	48.6753	0.0201	1
1.6327 4.6489	41.5487	0.0235	0

Onlooker bee Phase:

food Source	Maximize $f(x)$	Minimize fit	trial
3.1472 −4.0246	31.9645	0.0303	1
4.0579 − 3.0470	37.0428	0.0263	0
−3.7301 2.7604	38.4119	0.0254	0
4.1338 4.5751	48.6753	0.0201	1
1.6327 4.6489	41.5487	0.0235	0

Onlooker bee Phase:

Calculate the probabilities using $p_i = \frac{fit_i}{\sum fit_i}$

$P_1 = \frac{0.0303}{\Sigma}$

$P_2 = \frac{0.0263}{\Sigma}$

food Source	Maximize $f(x)$	Minimize fit	trial
3.1472 −4.0246	31.9645	0.0303	1
4.0579 −3.0470	37.0428	0.0263	0
−3.7301 2.7604	38.4119	0.0254	0
4.1338 4.5751	48.6753	0.0201	1
1.6327 4.6489	41.5487	0.0235	0

Σ

$p_i = [0.2415 \quad 0.2092 \quad 0.2020 \quad 0.1602 \quad 0.1871]$

Based on these probabilities, we implement the onlooker phase.

Onlooker bee Phase:

update solution

PROCEDURE

Select the random number (r)

Check, if r < prob,

If this condition satisfies, so we enter in to the loop for creating a new solution.

How to create a new solution is remains same procedure,

$$X_{new} = X + \phi(X - X_p)$$

food Source	Maximize $f(x)$	Minimize fit	trial
3.1472 −4.0246	31.9645	0.0303	1
4.0579 −3.0470	37.0428	0.0263	0
−3.7301 2.7604	38.4119	0.0254	0
4.1338 4.5751	48.6753	0.0201	1
1.6327 4.6489	41.5487	0.0235	0

$p_i = [0.2415 \quad 0.2092 \quad 0.2020 \quad 0.1602 \quad 0.1871]$

Onlooker bee Phase: 1st Bee

Select the random number r =0.23

Check, if r < prob, 0.23< 0.2415

food Source	Maximize $f(x)$	Minimize fit	trial
3.1472 −4.0246	31.9645	0.0303	1
4.0579 −3.0470	37.0428	0.0263	0
−3.7301 2.7604	38.4119	0.0254	0
4.1338 4.5751	48.6753	0.0201	1
1.6327 4.6489	41.5487	0.0235	0

$p_i = [0.2415 \quad 0.2092 \quad 0.2020 \quad 0.1602 \quad 0.1871]$

food Source	Maximize $f(x)$	Minimize fit	trial
....	.....	.....	...
....	.....	.....	...
....	.....	.....	...
....	.....	.....	...
....	.....	.....	...

Onlooker bee Phase: 1st Bee

Select the random number r = 0.23

Check, if r < prob, 0.23 < 0.2415

Select the random variable to change: 2

Select the random partner: 3

Create a new food location: Take $\phi = -0.69$

$X_{new} = 0.6571 \in (-5, 5)$ f(x) = 20.1914 ;

Thus, $X_1 = [3.1472 \quad 0.6571]$ fit = 0.0472

Perform greedy selection:

As 0.0303 < 0.0472; so No UPDATE.

Trial Value: trial(1) = 2

food Source	Maximize $f(x)$	Minimize fit	trial
3.1472 −4.0246	31.9645	0.0303	1 → 1+1
4.0579 −3.0470	37.0428	0.0263	0
−3.7301 2.7604	38.4119	0.0254	0
4.1338 4.5751	48.6753	0.0201	1
1.6327 4.6489	41.5487	0.0235	0

$p_i = [0.2415 \quad 0.2092 \quad 0.2020 \quad 0.1602 \quad 0.1871]$

food Source	Maximize $f(x)$	Minimize fit	trial
3.1472 −4.0246	31.9645	0.0303	2
....	.....	.....	...
....	.....	.....	...
....	.....	.....	...
....	.....	.....	...

Onlooker bee Phase: 2nd Bee

Select the random number r = 0.15

Check, if r < prob, 0.15 < 0.2092

Select the random variable to change: 1

Select the random partner: 5

Create a new food location: Take $\phi = 0.72$

$X_{new} = 5.8040 \notin (-5, 5)$ f(x) = 50.3311;

Thus, $X_2 = [5.0000 \quad -3.0470]$ fit = 0.0195

Perform greedy selection:

As 0.0195 < 0.0263, so UPDATE

Trial Value: trial(2)=0

food Source	Maximize $f(x)$	Minimize fit	trial
3.1472 −4.0246	31.9645	0.0303	1 → 0
4.0579 −3.0470	37.0428	0.0263	0
−3.7301 2.7604	38.4119	0.0254	0
4.1338 4.5751	48.6753	0.0201	1
1.6327 4.6489	41.5487	0.0235	0

$p_i = [0.2415 \quad 0.2092 \quad 0.2020 \quad 0.1602 \quad 0.1871]$

food Source	Maximize $f(x)$	Minimize fit	trial
3.1472 −4.0246	31.9645	0.0303	2
5.0000 −3.0470	50.3311	0.0195	0
....	.....	.....	...
....	.....	.....	...
....	.....	.....	...

Onlooker bee Phase: 3rd Bee

Select the random number r = 0.12

Check, if r < prob, 0.12 < 0.2020

Select the random variable to change: 1

Select the random partner: 2

Create a new food location: Take $\phi = 0.47$

$X_{new} = -7.8332 \notin (-5, 5)$ f(x) = 50.4639 ;

Thus, $X_3 = [-5.000 \quad 2.7604]$ fit = 0.0194

Perform greedy selection:

As 0.0194 < 0.0254, so UPDATE

Trial Value: trial (3) = 0

food Source	Maximize $f(x)$	Minimize fit	trial
3.1472 −4.0246	31.9645	0.0303	1 → 0
4.0579 −3.0470	37.0428	0.0263	0
−3.7301 2.7604	38.4119	0.0254	0
4.1338 4.5751	48.6753	0.0201	1
1.6327 4.6489	41.5487	0.0235	0

$p_i = [0.2415 \quad 0.2092 \quad 0.2020 \quad 0.1602 \quad 0.1871]$

food Source	Maximize $f(x)$	Minimize fit	trial
3.1472 −4.0246	31.9645	0.0303	2
5.0000 −3.0470	50.3311	0.0195	0
−5.000 2.7604	50.4639	0.0194	0
....	.....	.....	...
....	.....	.....	...

Onlooker bee Phase: 4th Bee

Select the random number r = 0.35

Check, if r < prob, 0.35 > 0.1602

Select the random variable to change:

Select the random partner:

Create a new food location:

Perform greedy selection:

Trial Value:

food Source	Maximize $f(x)$	Minimize fit	trial
3.1472 −4.0246	31.9645	0.0303	1
4.0579 −3.0470	37.0428	0.0263	0
−3.7301 2.7604	38.4119	0.0254	0
4.1338 4.5751	48.6753	0.0201	1
1.6327 4.6489	41.5487	0.0235	0

p_i = [0.2415 0.2092 0.2020 0.1602 0.1871]

food Source	Maximize $f(x)$	Minimize fit	trial
3.1472 −4.0246	31.9645	0.0303	2
5.0000 −3.0470	50.3311	0.0195	0
−5.000 2.7604	50.4639	0.0194	0
4.1338 4.5751	48.6753	0.0201	1
....	.....	.....	...

Onlooker bee Phase: 4th Bee (which is 5th food source)

Select the random number r = 0.13

Check, if r < prob, 0.13 < 0.1871

Select the random variable to change: 1

Select the random partner: 1

Create a new food location: Take $\phi = 0.54$

$X_{new} = 5.6687 \notin (-5, 5)$ f(x) = 45.7676

$= 5$

Thus, X_4 = [1.6327 5.0000] fit = 0.0214

Perform greedy selection:

As 0.0214 < 0.0235; so UPDATE

Trial Value: trial(5) = 0

food Source	Maximize $f(x)$	Minimize fit	trial
3.1472 −4.0246	31.9645	0.0303	1
4.0579 −3.0470	37.0428	0.0263	0
−3.7301 2.7604	38.4119	0.0254	0
4.1338 4.5751	48.6753	0.0201	1
1.6327 4.6489	41.5487	0.0235	0

p_i = [0.2415 0.2092 0.2020 0.1602 0.1871]

food Source	Maximize $f(x)$	Minimize fit	trial
3.1472 −4.0246	31.9645	0.0303	2
5.0000 −3.0470	50.3311	0.0195	0
−5.000 2.7604	50.4639	0.0194	0
4.1338 4.5751	48.6753	0.0201	1
1.6327 5.0000	45.7676	0.0214	0

Onlooker bee Phase: 5th Bee (1st food s~)

Select the random number r = 0.19

Check, if r < prob, 0.19 < 0.2415

Select the random variable to change: 2

Select the random partner: 2

Create a new food location: Take $\phi = -0.45$

$X_{new} = -3.5847 \in (-5, 5)$ f(x) = 28.9921 ;

Thus, X_5 = [3.1472 −3.5847] fit = 0.0333

Perform greedy selection:

As 0.0303 < 0.0333; so No update.

Trial Value: trial(1) = 3

food Source	Maximize $f(x)$	Minimize fit	trial
3.1472 −4.0246	31.9645	0.0303	1
4.0579 −3.0470	37.0428	0.0263	0
−3.7301 2.7604	38.4119	0.0254	0
4.1338 4.5751	48.6753	0.0201	1
1.6327 4.6489	41.5487	0.0235	0

p_i = [0.2415 0.2092 0.2020 0.1602 0.1871]

food Source	Maximize $f(x)$	Minimize fit	trial
3.1472 −4.0246	31.9645	0.0303	3
5.0000 −3.0470	50.3311	0.0195	0
−5.000 2.7604	50.4639	0.0194	0
4.1338 4.5751	48.6753	0.0201	1
1.6327 5.0000	45.7676	0.0214	0

Difference between Employed & Onlooker Bee Phases

Employed –

all food source values are used to generate a new (better) values.

Onlooker –

a food source may or may not generate a new solution, that depends on the random number selected for a particular onlooker bee as well as the probabilities of the food source.

Memorize the best answer

My objective function is of Maximization

Best food source $|-5.000 \quad 2.7604|$ (x_1, x_2)

Best f(x) = 50.4639

food Source	Maximize $f(x)$	Minimize fit	trial
3.1472 −4.0246	31.9645	0.0303	3
5.0000 −3.0470	50.3311	0.0195	0
−5.000 2.7604	50.4639	0.0194	0
4.1338 4.5751	48.6753	0.0201	1
1.6327 5.0000	45.7676	0.0214	0

SCOUT Phase.

Remember, Scout phase may or may not be encountered in every iteration.

Firstly, we need to check, whether Scout phase bee implemented or not?

food Source	Maximize $f(x)$	Minimize fit	trial
3.1472 −4.0246	31.9645	0.0303	3
5.0000 −3.0470	50.3311	0.0195	0
−5.000 2.7604	50.4639	0.0194	0
4.1338 4.5751	48.6753	0.0201	1
1.6327 5.0000	45.7676	0.0214	0

SCOUT Phase.

Remember, Scout phase may or may not be encountered in every iteration.

Firstly, we need to check, whether Scout phase bee implemented or not?

That decision is taken on the basis of trial values & limit.

food Source	Maximize $f(x)$	Minimize fit	trial
3.1472 −4.0246	31.9645	0.0303	3
5.0000 − 3.0470	50.3311	0.0195	0
−5.000 2.7604	50.4639	0.0194	0
4.1338 4.5751	48.6753	0.0201	1
1.6327 5.0000	45.7676	0.0214	0

Initially, we set limit = 1

SCOUT Phase.

Since trial(1)>limit, so we apply scout phase here.

3 > 1

food Source	Maximize $f(x)$	Minimize fit	trial
3.1472 −4.0246	31.9645	0.0303	3
5.0000 − 3.0470	50.3311	0.0195	0
−5.000 2.7604	50.4639	0.0194	0
4.1338 4.5751	48.6753	0.0201	1
1.6327 5.0000	45.7676	0.0214	0

Initially, we set limit = 1

SCOUT Phase.

Since trial(1)>limit, so we apply scout phase here.

In it, we discard this solution and randomly generate a New solution between the given domain (-5, 5).

$$X = L + rand(U - L)$$

Randomly choose a new solution as

[3.6045 −1.7170] f(x) = 25.4710

fit= 0.0378

food Source	Maximize $f(x)$	Minimize fit	trial
~~3.1472 −4.0246~~	~~31.9645~~	~~0.0303~~	~~3~~
5.0000 − 3.0470	50.3311	0.0195	0
−5.000 2.7604	50.4639	0.0194	0
4.1338 4.5751	48.6753	0.0201	1
1.6327 5.0000	45.7676	0.0214	0

food Source	Maximize $f(x)$	Minimize fit	trial
3.6045 −1.7170	25.4710	0.0378	0
5.0000 − 3.0470	50.3311	0.0195	0
−5.000 2.7604	50.4639	0.0194	0
4.1338 4.5751	48.6753	0.0201	1
1.6327 5.0000	45.7676	0.0214	0

SCOUT Phase.

Since trial(1)>limit, so we apply scout phase here.

In it, we discard this solution and randomly generate a New solution between the given domain (-5, 5).

$$X = L + rand(U - L)$$

food Source	Maximize $f(x)$	Minimize fit	trial
3.1472 4.0246	31.9645	0.0303	3
5.0000 −3.0470	50.3311	0.0195	0
−5.000 2.7604	50.4639	0.0194	0
4.1338 4.5751	48.6753	0.0201	1
1.6327 5.0000	45.7676	0.0214	0

Remember:

There is no greedy selection in SCOUTT phase.

food Source	Maximize $f(x)$	Minimize fit	trial
3.6045 −1.7170	25.4710	0.0378	0
5.0000 −3.0470	50.3311	0.0195	0
−5.000 2.7604	50.4639	0.0194	0
4.1338 4.5751	48.6753	0.0201	1
1.6327 5.0000	45.7676	0.0214	0

Iteration 1:

Best food source |−5.000 2.7604|

Best f(x) = 50.4639

food Source	Maximize $f(x)$	Minimize fit	trial
3.6045 −1.7170	25.4710	0.0378	0
5.0000 −3.0470	50.3311	0.0195	0
−5.000 2.7604	50.4639	0.0194	0
4.1338 4.5751	48.6753	0.0201	1
1.6327 5.0000	45.7676	0.0214	0

Iteration 5:

Best food source [-5.0000 3.8737]

Best f(x) = 67.8691

food Source	Maximize $f(x)$	Minimize fit	trial
-2.3703 3.8152	42.7367		
-0.4946 -4.1618	21.7531		
-5.0000 3.8737	67.8691		
4.5729 4.5751	51.3679		
2.6606 5.0000	47.0970		

it -> 19 (88)

Iteration 20

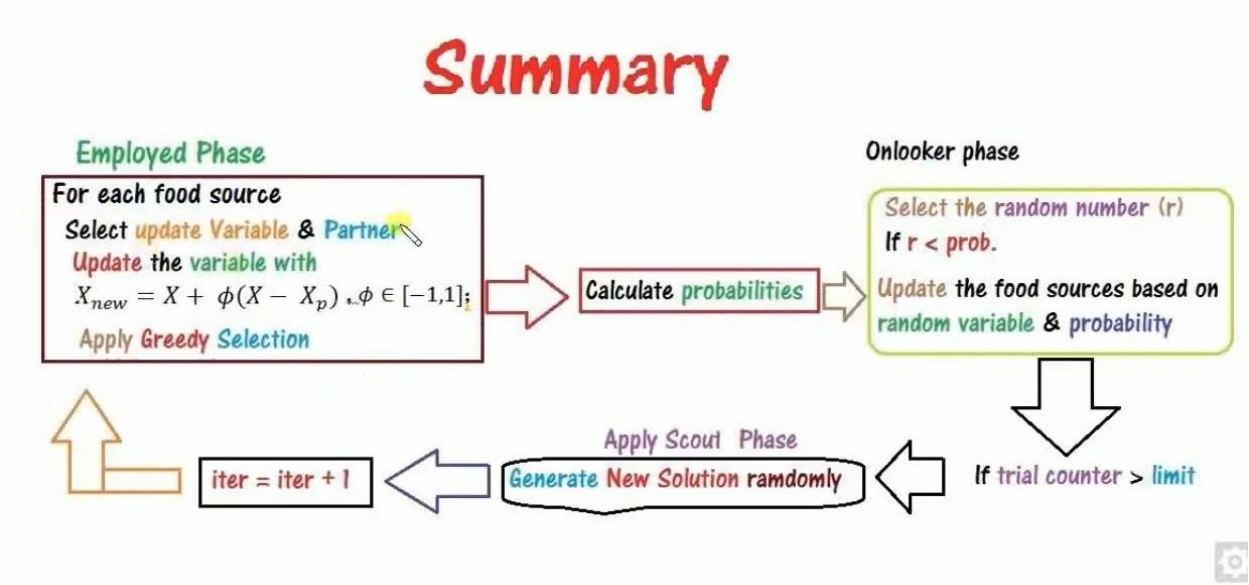
Best food source [-5.000 5.000]

Best f(x) = 88.0000

food Source	Maximize $f(x)$	Minimize fit	trial
-5.0000 4.8716	85.5768		
-2.6008 -3.7668	-6.1126		
5.0000 4.8795	56.9298		
4.5729 4.5751	51.3679		
4.2400 5.0000	53.2573		

$|f(x_{i+1}) - f(x_i)| < \epsilon$

Summary


Employed Phase
For each food source
Select update Variable & Partner
Update the variable with
$X_{new} = X + \phi(X - X_p)$, $\phi \in [-1,1]$;
Apply Greedy Selection
Calculate probabilities
Onlooker phase
Select the random number (r)
If r < prob.
Update the food sources based on random variable & probability
If trial counter > limit
Apply Scout Phase
Generate New Solution ramdomly
iter = iter + 1