Artificial Bee Colony Algorithm

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Optimization

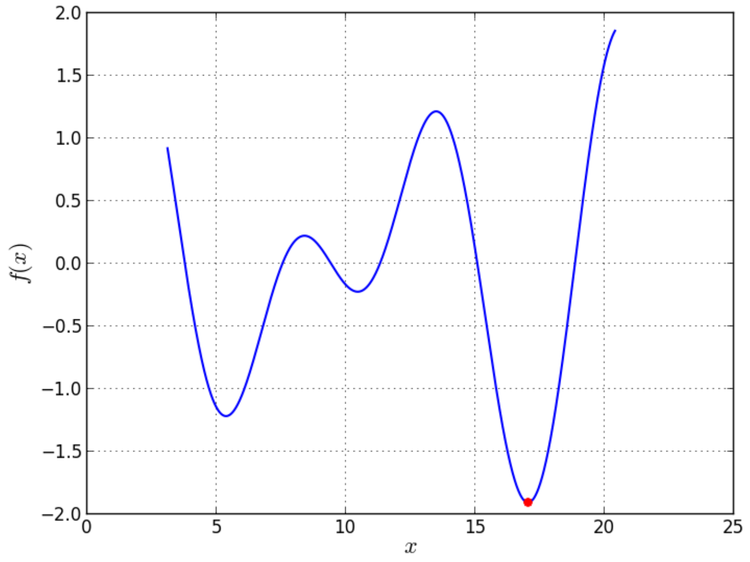
$x = (x_1, x_2, \ldots, x_i, \ldots x_n)$ Decision or design variables/parameters

$f(x) = f(x_1, x_2, \ldots x_n)$ Objective Function

$h_j = h_j(x_1, x_2, \ldots x_n) = 0, \quad 1 \leq \mathrm{j} \leq \mathrm{p}$ Equality constraints

$g_i = g_i(x_1, x_2, \ldots x_n) \leq 0, \quad 1 \leq \mathrm{i} \leq \mathrm{m}$ İnequality constraints

$f(x^*) \leq f(x)$ x^* represents optimum solution



Some problems may consist of more than one objective function.

Classification of Optimization Techniques

Mathematical programming techniques

(Based on the geometrical properties of the problem)

Simplex Algorithm, Interior point Algorithm

Steepest Decent, Newton's Method, Quasi-Newton

Branch and Bound, Cutting Planes

Other Techniques

Nelder Mead/Simplex Search

Fibonacci Method

Golden Section Method

Hooke-Jeeves pattern search method

Powel's conjugate Direction Method

Classification of Optimization Techniques

Metaheuristic Techniques

Genetic Algorithm(GA)
Particle Swarm optimization
Differential evolution(DE)
Teaching learning Base optimization(TLBO)
Grey Wolf Optimization
Artificial Bee Colony Algorithm

Heuristic algorithms can not be proven to converge to the optimum solution in the solution space. The have the property of convergence but they can not guarantee the exact solution. They can only guarantee a solution close to the exact solution.

Applications

Time tabling (limited runways)
Production Planning and scheduling
Civil engineering Structures
Design of aircraft and aerospace
Design electrical mechinery
Design of Pump, turbines and heat exchanger
Mechine learnig and Data science
Automobile Design
Antena Design

Why nature-inspired optimization methods

Dimensionality

Multimodality

Complex Constraints

Interacting among parameters

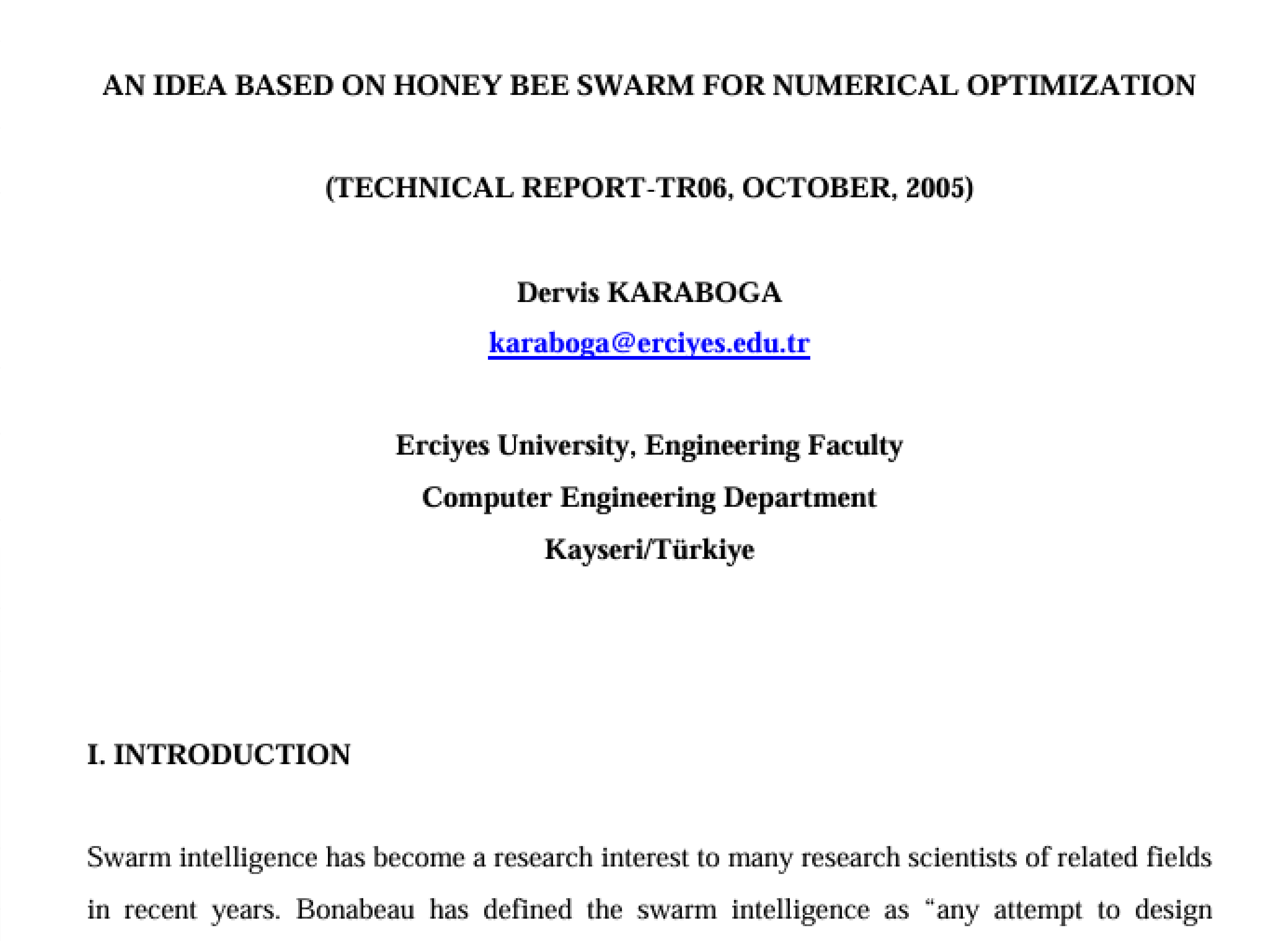
Uncertainty in modeling

Dynamic Objectives

Multiple objectives

Computational cost

Artificial Bee Colony Algorithm



AN IDEA BASED ON HONEY BEE SWARM FOR NUMERICAL OPTIMIZATION

(TECHNICAL REPORT-TR06, OCTOBER, 2005)

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I. INTRODUCTION

Swarm intelligence has become a research interest to many research scientists of related fields in recent years. Bonabeau has defined the swarm intelligence as “any attempt to design

Type of Bees

The Employed Bee

These bees first collect the food from the source
Share information about its location with onlookers
Food is also caled nectar.

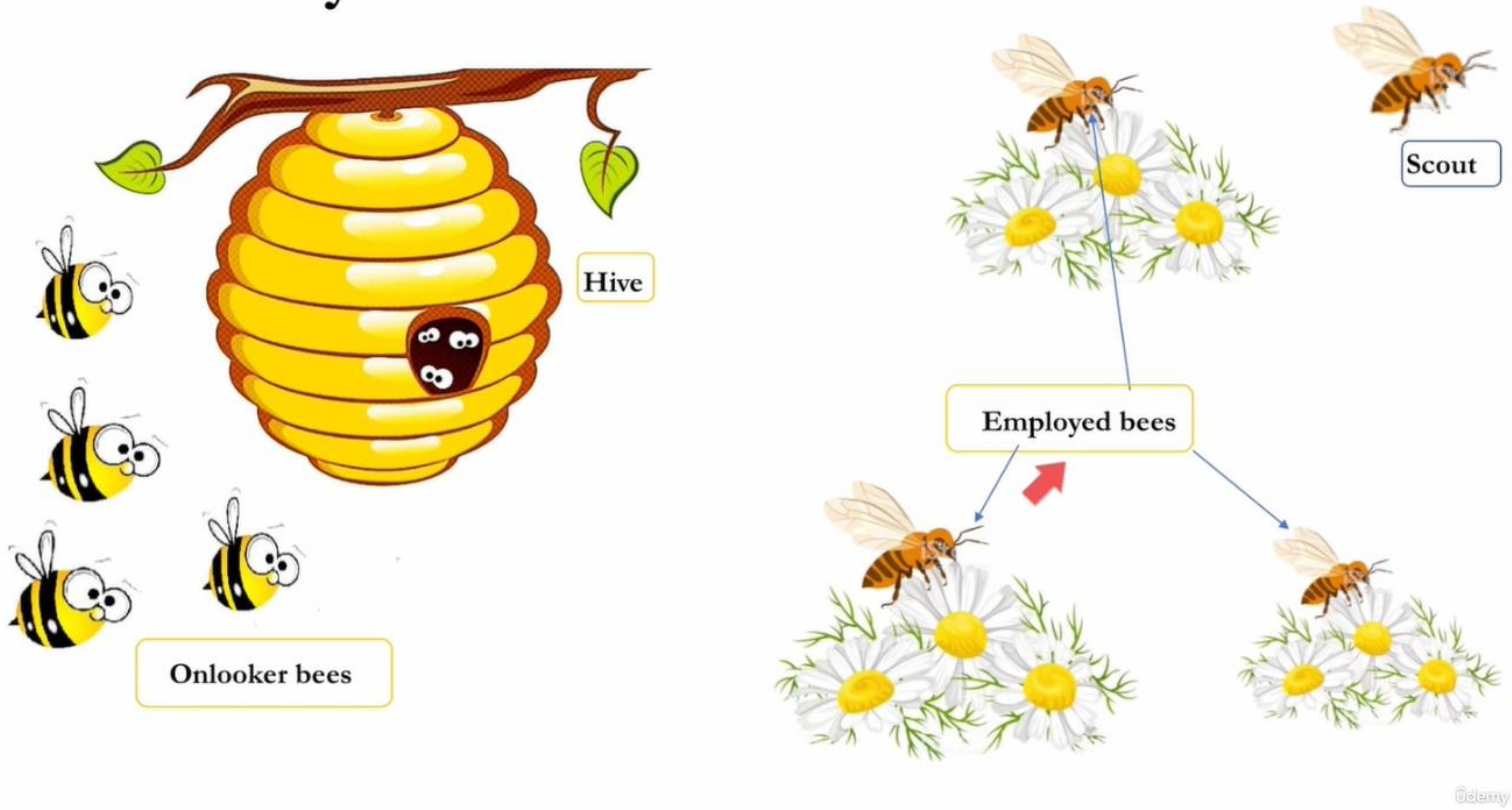
The Onlooker Bee

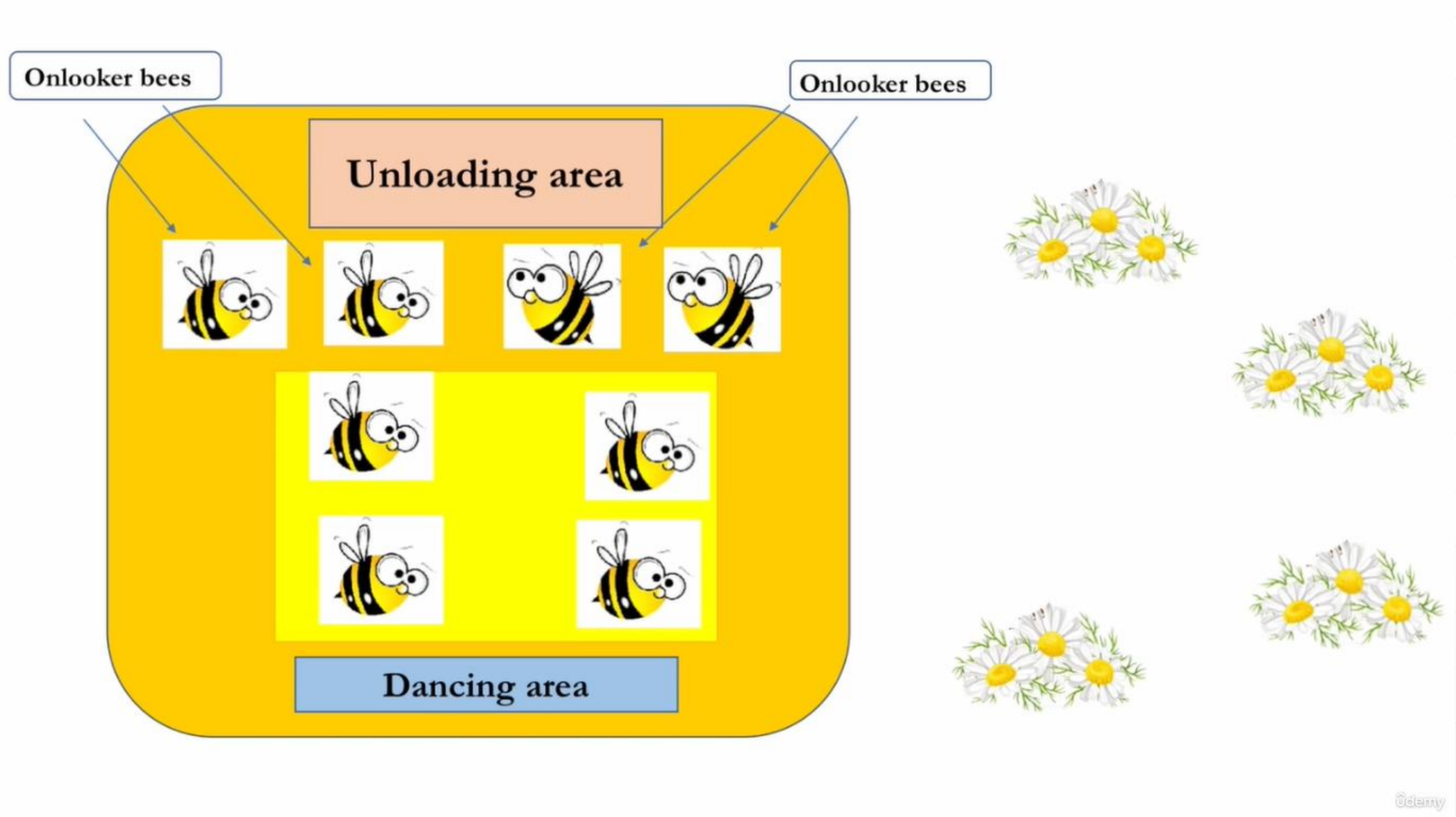
Receive the information of the food source from the employed bees and select one of the best food source to gather the food

The Scout Bee

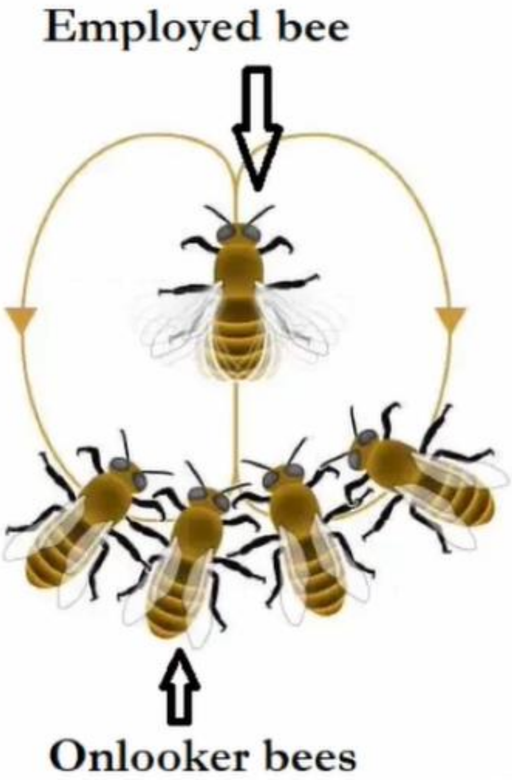
Responsible for finding new food source whenever required

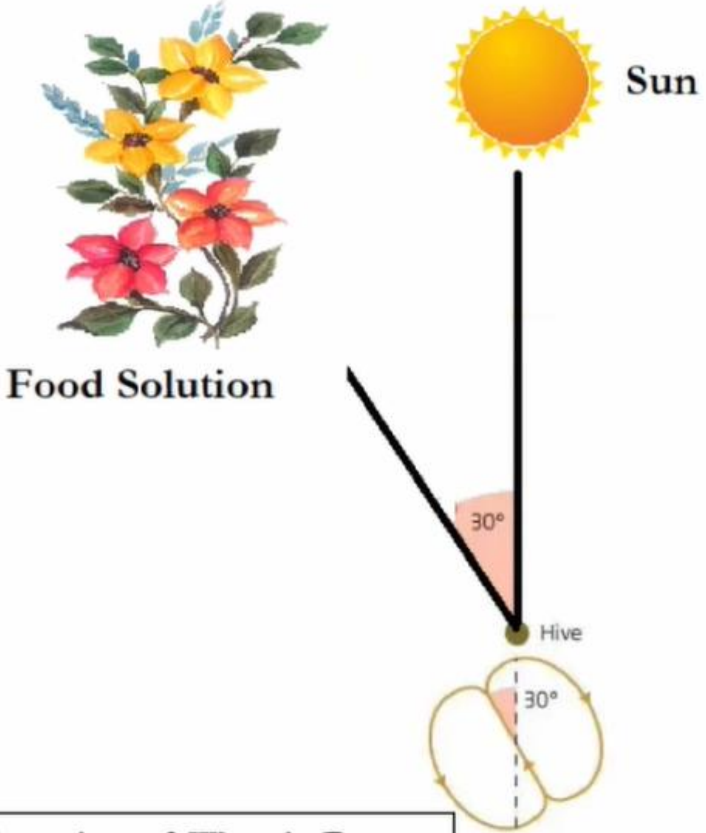
Honey bee food Search Mechanism



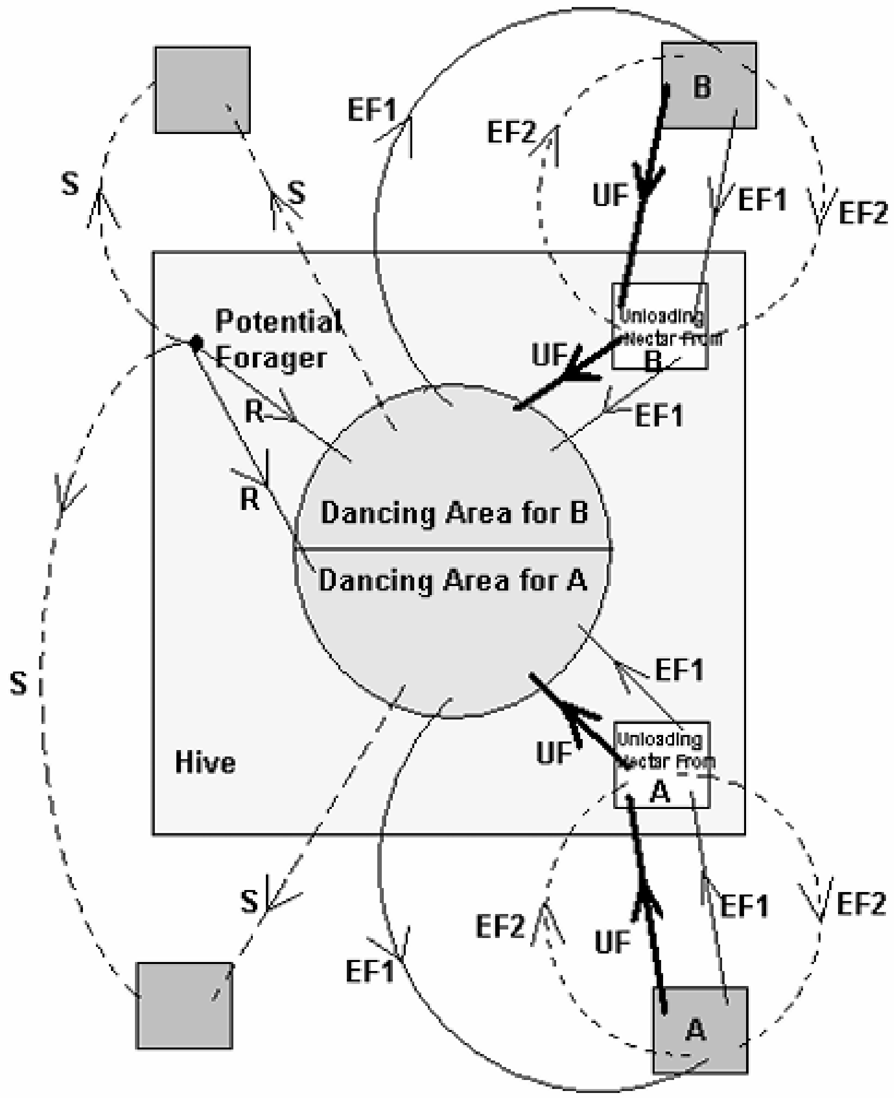

Onlooker bees
Onlooker bees
Unloading area
Dancing area
Udemy

Waggle Dance





Distance = Duration of Waggle Dance



B
EF1
EF2
UF
EF1
EF2
S
S
Potential Forager
Unloading Nectar From B
UF
EF1
R
R
Dancing Area for B
Dancing Area for A
S
EF1
UF
Unloading Nectar From A
Hive
S
EF2
UF
EF1
EF2
EF1
A

Self Organization

In the case of honey bees, the basic properties on which self organization relies are as follows:

1- **Positive feedback**: As the nectar amount of food sources increases, the number of onlookers visiting them increases, too.

2- **Negative feedback**: The exploitation process of poor food sources is stopped by bees.

3- **Fluctuations**: The scouts carry out a random search process for discovering new food sources.

4- **Multiple interactions**: Bees share their information about food sources with their nest mates on the dance area.

ABC Algorithm

The ABC Algorithm comprises four phases,

İnitilazation phase

Common in all swarm inteligence methods

Employed bee Phase

Bees Associated with specific food source

Onlooker bee phase

Waiting in hive and watch the waggle dance

Scout bee phase

Bees with abondened food source, start searching

Initialization Phase

$$x_{ij} = x_{j,min} + rand(0,1) * (x_{j,max} - x_{j,min})$$

«i» be position of food source or set of posible solutions (randomly generated)

$$X_i \rightarrow \begin{vmatrix} x_{ij} & x_{12} & x_{13} \\ x_{21} & x_{22} & x_{23} \\ x_{31} & x_{32} & x_{33} \end{vmatrix}$$

Initialization Phase

Objective function values are obtained from the food source position

The fitness value of solutions are calculated

$$fit_k = \begin{cases} \frac{1}{(1+f_k)} & \text{if } f_k \geqslant 0 \\ 1 + abs(f_k) & if\ f_k \leqslant 0 \end{cases}$$

At this stage trail encounter is set to zero

Employed Bee Phase

Change in food position by employed bee

$$v_{ij} = x_{ij} + \phi_{ij} * (x_{ij} - x_{kj})$$

ϕ random number between [-1,1]

$$X_i \rightarrow \begin{vmatrix} x_{ij} & x_{12} & x_{13} \\ x_{21} & x_{22} & x_{23} \\ x_{31} & x_{32} & x_{33} \end{vmatrix}$$

Onlooker Bee Phase

Probability

$$P_i = \frac{Fit(X_i)}{\sum_{k=1}^{S} Fit(X_k)}$$

Calculation of the newposition

$$v_{ij} = x_{ij} + \phi_{ij} * (x_{ij} - x_{kj})$$

ϕ random number between [-1,1]

$$X_i \rightarrow \begin{vmatrix} x_{ij} & x_{12} & x_{13} \\ x_{21} & x_{22} & x_{23} \\ x_{31} & x_{32} & x_{33} \end{vmatrix}$$

Scout Bee Phase

İf particular solution is not improved after predetermined trials, ignore it and create new solution randomly in the search space

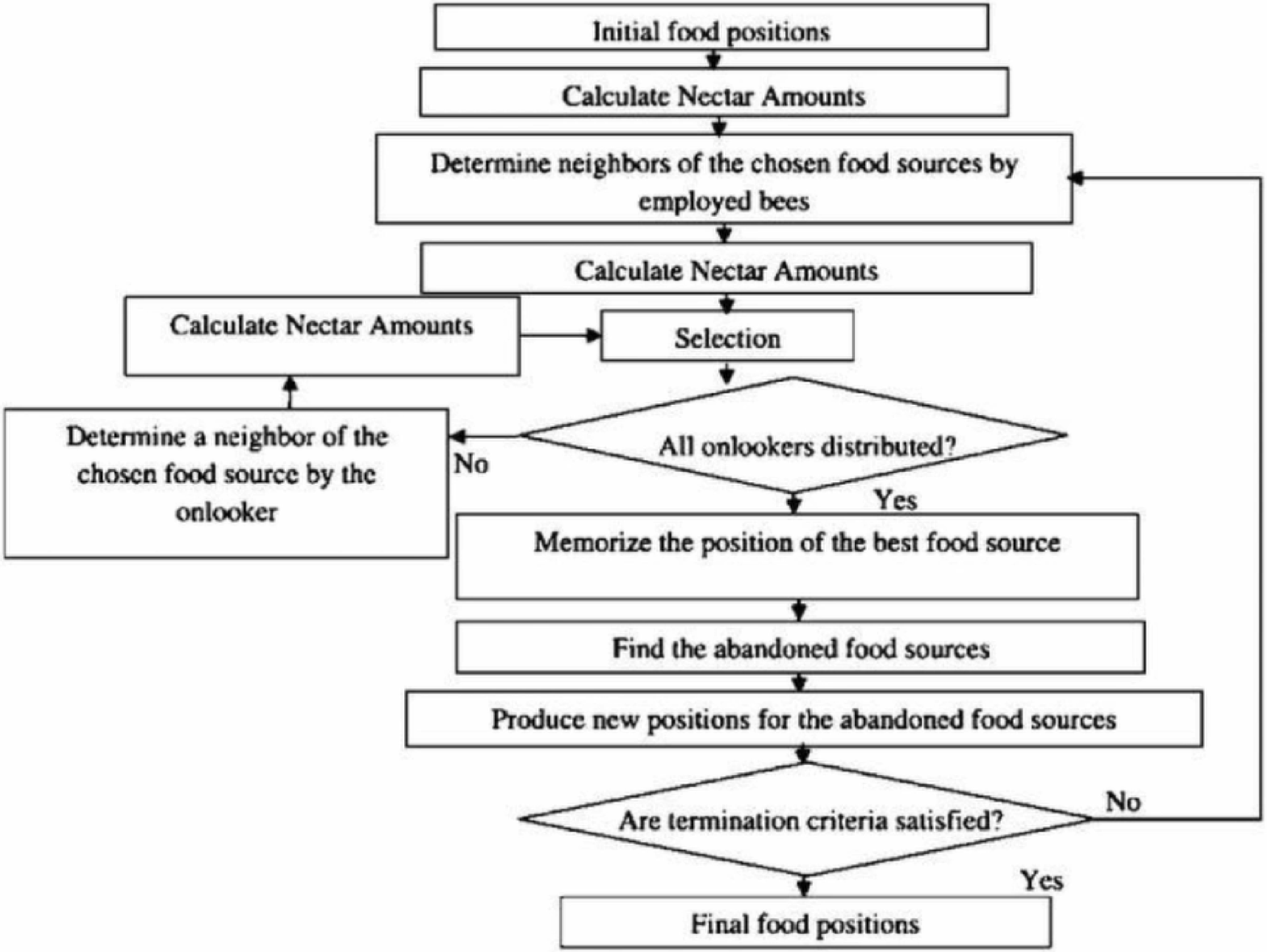
$$x_{ij} = x_{j,min} + rand(0,1) * (x_{j,max} - x_{j,min})$$

$$X_i \rightarrow \begin{vmatrix} x_{ij} & x_{12} & x_{13} \\ x_{21} & x_{22} & x_{23} \\ x_{31} & x_{32} & x_{33} \end{vmatrix}$$

1. İnitialize the population of solution x_{ij}
2. Evaluate the population
3. Cycle=1
4. Repeat
5. Produce new solutions (food source positions) v_{ij} in the nebourhood of x_{ij} for the employed bees using the formula $v_{ij} = x_{ij} + \phi_{ij} * (x_{ij} - x_{kj})$ (k is the solution in the nebourhood of i, ϕ is the random number in the range of [-1,1]) and evaluate them.
6. Apply greedy selection process between x_i and v_i.
7. Calculate the probability values P_i forthe solution x_{ij} by means of their fitness values using the equetion $P_i = Fit_i / \sum Fit_i$. In order to calculate fitness values of solutions we employed the folowing equation .

$$fit_k = \begin{cases} \frac{1}{(1+f_k)} & \text{if } f_k \geqslant 0 \\ 1 + abs(f_k) & \text{if } f_k \leqslant 0 \end{cases}$$

8. Produce the new solutions v_i for the onlookers from the solutions x_i selected depending on P_i and evaluate them.
9. Apply the greedy selection process for the onlookers between x_i and v_i.
10. Determine the abandoned solution, if exists, and replace it with a new randomly produced solution x_i for the scout using the equation $x_{ij} = x_{j,min} + rand(0,1) * (x_{j,max} - x_{j,min})$
11. Memorize the best food source(solution) achieved so far.
12. Cycle =cycle + 1
13. Until cycle = maximum cycle number.


Initial food positions
Calculate Nectar Amounts
Determine neighbors of the chosen food sources by employed bees
Calculate Nectar Amounts
Calculate Nectar Amounts
Selection
All onlookers distributed?
No
Determine a neighbor of the chosen food source by the onlooker
Yes
Memorize the position of the best food source
Find the abandoned food sources
Produce new positions for the abandoned food sources
Are termination criteria satisfied?
No
Yes
Final food positions

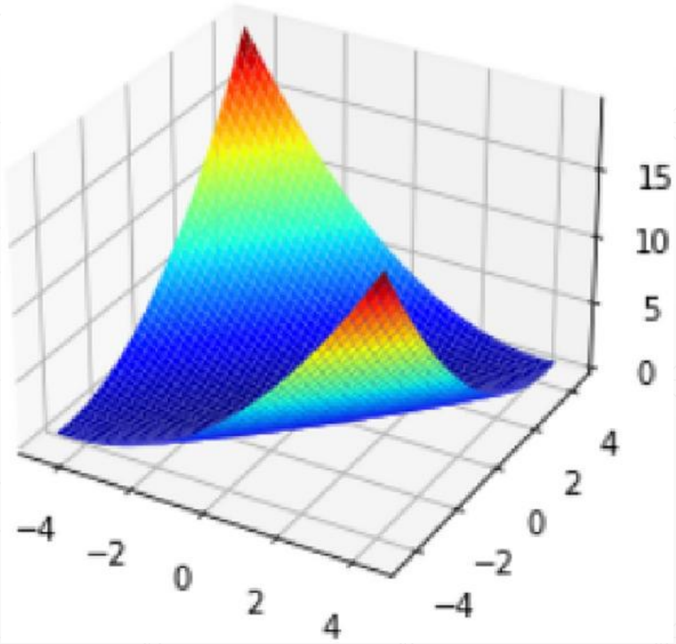
İmplementation

Matyas Function

$$f(x,y) = 0.26(x^2 + y^2) - 0.48xy$$

$$f(0,0) = 0$$

$$-10 \leq x, y \leq 10$$



Rosenbrock Function

$$f(x,y) = (1-x)^2 + 100(y-x^2)^2, \quad \text{subject to } \mathrm{x}^2 + \mathrm{y}^2 \leq 2$$

$$f(1,1) = 0 \qquad -1.5 \leq x, y \leq 1.5$$