Artificial Bee Colony Algorithm

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South Asian University

(Knowledge without borders)

- SAU is an international university established by the eight member nations of South Asian Association for Regional Co-operation (SAARC) viz. Afghanistan, Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan and Sri Lanka.
- SAU started its operations from the academic year 2010.
- Courses (All PG): Development Economics, Computer Science, Biotechnology, Mathematics, Sociology, International Relations and Law.
- Present Campus at Akbar Bhawan Campus in Chanakyapuri, New Delhi
- Permanent Campus at Maidan Garhi, South Delhi where the construction is starting very soon.

Contents

- Artificial Bee Colony Algorithm

BEHAVIOUR OF HONEY BEE SWARM

The minimal model of forage selection that leads to the emergence of collective intelligence of honey bee swarms consists of three essential components:

- food sources,
- employed foragers
- unemployed foragers

- Food Sources: The value of a food source depends on many factors such as its proximity to the nest, its richness or concentration of its energy, and the ease of extracting this energy. For the sake of simplicity, the "profitability" of a food source can be represented with a single quantity.

- Employed foragers: They are associated with a particular food source which they are currently exploiting or are "employed" at. They carry with them information about this particular source, its distance and direction from the nest, the profitability of the source and share this information with a certain probability.

- Unemployed foragers: They are continually at look out for a food source to exploit. There are two types of unemployed foragers:
  - Scouts: searching the environment surrounding the nest for new food sources and
  - Onlookers: waiting in the nest and establishing a food source through the information shared by employed foragers.

The mean number of scouts averaged over conditions is about 5-10%.

Foraging

Foraging is the most important task in the hive. Many studies have investigated the foraging behavior of each individual bee:

- External information: such as odor, location information in the waggle dance, the presence of other bees at the source or between the hive and the source
- Internal information: such as remembered source location or source odor

Foraging process starts with leaving the hive of a forager in order to search food source to gather nectar. After finding a flower for herself, the bee stores the nectar in her honey stomach. Based on the conditions such as richness of the flower and the distance of the flower to the hive, the bee fills her stomach in about 30–120 min and honey making process begins with the secretion of an enzyme on the nectar in her stomach. After coming back to the hive, the bee unloads the nectar to empty honeycomb cells and some extra substances are added in order to avoid the fermentation and the bacterial attacks. Filled cells with the honey and enzymes are covered by wax.

Dance

After unloading the nectar, the forager bee which has found a rich source performs special movements called “dance” on the area of the comb in order to share her information about the food source such as how plentiful it is, its direction and distance and recruits the other bees for exploiting that rich source.

While dancing, other bees touch her with their antenna and learn the scent and the taste of the source she is exploiting. She dances on different areas of the comb in order to recruit more bees and goes on to collect nectar from her source.

Artificial Bee Colony Algorithm (ABC)

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Dance (Cont…)

There are different dances performed by bees depending on the distance information of the source:

- Round dance: If the distance of the source to the hive is less than 100 meters. Round dance does not give direction information.
- waggle dance: When the source is far away. In case of waggle dance, direction of the source according to the sun is transferred to other bees. Longer distances cause quicker dances.
- Tremble dance: When the foraging bee perceives a long delay in unloading its nectar.

9

Artificial Bee Colony (ABC)

- A particular intelligent behavior of a honey bee swarm, foraging behavior, is considered and a new artificial bee colony (ABC) algorithm simulating this behavior of real honey bees is developed for solving multidimensional and multimodal optimization problems.

- In other words, ABC is developed based on inspecting the behaviors of real bees on finding nectar and sharing the information of food sources to the bees in the hive.

Types of bees in ABC

In the ABC algorithm, the colony of artificial bees contains three groups of bees:

- Employed bees,
- Onlookers and
- Scouts

Artificial Bee Colony (ABC) (2)

- The Employed Bee:
  It stays on a food source and provides the neighborhood of the source in its memory.
- The Onlooker Bee:
  It gets the information of food sources from the employed bees in the hive and select one of the food source to gathers the nectar.
- The Scout:
  It is responsible for finding new food, the new nectar, sources.

Distribution of Bees

- In the ABC algorithm, first half of the colony consists of employed artificial bees and the second half constitutes the onlookers.
- For every food source, there is only one employed bee. In other words, the number of employed bees is equal to the number of food sources around the hive.
- The employed bee whose food source is exhausted by the employed and onlooker bees becomes a scout.

Artificial Bee Colony (ABC) (3)

- Procedures of ABC:
  - Initialize (Move the scouts).
  - Move the onlookers.
  - Move the scouts only if the counters of the employed bees hit the *limit*.
  - Update the memory
  - Check the termination condition

Pseudo Code

1: Initialize the population of solutions $x_{i,j}$

2: Evaluate the population

3: cycle=1

4: repeat

5: Produce new solutions (food source positions) $\upsilon_{i,j}$ in the neighbourhood of $x_{i,j}$ for the employed bees using the formula $\upsilon_{i,j} = x_{i,j} + \Phi_{ij}(x_{i,j} - x_{k,j})$ (k is a solution in the neighbourhood of i, Φ is a random number in the range [-1,1])and evaluate them

6: Apply the greedy selection process between x_i and υ_i

7: Calculate the probability values P_i for the solutions x_i by means of their fitness values using the equation (1)

$$P_i = \frac{fit_i}{\sum_{i=1}^{SN} fit_i} \qquad (1)$$

In order to calculate the fitness values of solutions we employed the following equation (eq. 2):

$$fit_i = \begin{cases} \frac{1}{1+f_i} & if\ f_i \geq 0 \\ 1+abs(f_i) & if\ f_i < 0 \end{cases} \qquad (2)$$

Normalize P_i values into [0,1]

8: Produce the new solutions (new positions) υ_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 υ_i

10: Determine the abandoned solution (source), if exists, and replace it with a new randomly produced solution x_i for the scout using the equation (3)

$$x_{ij}=min_j+rand(0,1)*(max_j-min_j) \quad (3)$$

11: Memorize the best food source position (solution) achieved so far

12: cycle=cycle+1

13: until cycle= Maximum Cycle Number (MCN)

Step by Step Procedure of ABC

Consider the optimization problem as follows:

$$Minimize\ f(x) = x_1^2 + x_2^2, \qquad -5 \le x_1, x_2 \le 5$$

Control Parameters of ABC Algorithm are set as;

- Colony size, CS = 6
- Limit for scout, L = (CS*D)/2 = 6

and dimension of the problem, D = 2

First, we initialize the positions of 3 food sources (CS/2) of employed bees, randomly using uniform distribution in the range (-5, 5).

x =

1.4112	-2.5644
0.4756	1.4338
-0.1824	-1.0323

f(x) values are;

8.5678
2.2820
1.0990

Fitness function: $fit_i = \begin{cases} \frac{1}{1+f_i} & if \ f_i \geq 0 \\ 1 + abs(f_i) & if \ f_i < 0 \end{cases}$

Initial fitness vector is:

0.1045
0.3047
0.4764

Maximum fitness value is 0.4764, the quality of the best food source.

Cycle=1

//Employed bees phase

- 1st employed bee

  - $v_{i,j} = x_{i,j} + \Phi_{ij}(x_{i,j} - x_{k,j})$ with this formula, produce a new solution.
    k=1 //k is a random selected index.
    j=0 //j is a random selected index.
    Φ = 0.8050 // Φ is randomly produced number in the range [-1, 1].
    v_0=
    2.1644 -2.5644

  - Calculate $f(v_0)$ and the fitness of v_0.

    $f(v_0)$ = 11.2610 and the fitness value is 0.0816.

  - Apply greedy selection between x_0 and v_0

    0.0816 < 0.1045, the solution 0 couldn't be improved,
    increase its trial counter.

- 2nd employed bee

  - $v_{i,j} = x_{i,j} + \Phi_{ij}(x_{i,j} - x_{k,j})$ with this formula produce a new solution.
    k=2 //k is a random selected solution in the neighborhood of i.
    j=1 //j is a random selected dimension of the problem.
    Φ = 0.0762 // Φ is randomly produced number in the range [-1, 1].
    v_1=
    0.4756 1.6217

  - Calculate $f(v_1)$ and the fitness of v_1.

    $f(v_1)$ = 2.8560 and the fitness value is 0.2593.

  - Apply greedy selection between x_1 and v_1

    0.2593 < 0.3047, the solution 1 couldn't be improved, increase its trial counter.

- 3rd employed bee

  - $v_{i,j} = x_{i,j} + \Phi_{ij}(x_{i,j} - x_{k,j})$ with this formula produce a new solution.
    k=0 //k is a random selected solution in the neighborhood of i.
    j=0 //j is a random selected dimension of the problem.
    Φ = -0.0671 // Φ is randomly produced number in the range [-1, 1].
    υ_2=
    -0.0754 -1.0323
  - Calculate $f(\upsilon_2)$ and the fitness of υ_2.

    $f(\upsilon_2)$ = 1.0714 and the fitness value is 0.4828.

  - Apply greedy selection between x_2 and υ_2.

    0.4828 > 0.4764, the solution 2 was improved, set its trial counter as 0 and replace the solution x_2 with υ_2.

//Calculate the probability values p for the solutions x by means of their fitness
//values by using the formula; $p_i = \frac{fit_i}{\sum_{i=1}^{CS/2} fit_i}$.

$p =$

0.1172
0.3416
0.5412

//Onlooker bees phase
//Produce new solutions v_i for the onlookers from the solutions x_i selected
//depending on p_i and evaluate them.

- 1st onlooker bee
  - i=2

    υ_2=

    -0.0754 -2.2520
  - Calculate $f(\upsilon_2)$ and the fitness of υ_2.

    $f(\upsilon_2)$ = 5.0772 and the fitness value is 0.1645.
  - Apply greedy selection between x_2 and υ_2

    0.1645 < 0.4828, the solution 2 couldn't be improved, increase its trial counter.

- 2^{nd} onlooker bee
  - i=1
    υ_1=
    0.1722 1.4338
  - Calculate $f(\upsilon_1)$ and the fitness of υ_1.

    $f(\upsilon_1)$ = 2.0855 and the fitness value is 0.3241.
  - Apply greedy selection between x_1 and υ_1

    0.3241 > 0.3047, the solution 1 was improved, set its trial counter as 0 and replace the solution x_1 with υ_1.

3rd onlooker bee

- i=2

  υ_2=

  0.0348 -1.0323

- Calculate $f(\upsilon_2)$ and the fitness of υ_2.

  $f(\upsilon_2)$ = 1.0669 and the fitness value is 0.4838.

- Apply greedy selection between x_2 and υ_2

  0.4838 > 0.4828, the solution 2 was improved, set its trial counter as 0 and replace the solution x_2 with υ_2.

//Memorize best
Best =

0.0348 -1.0323

//Scout bee phase
TrialCounter =

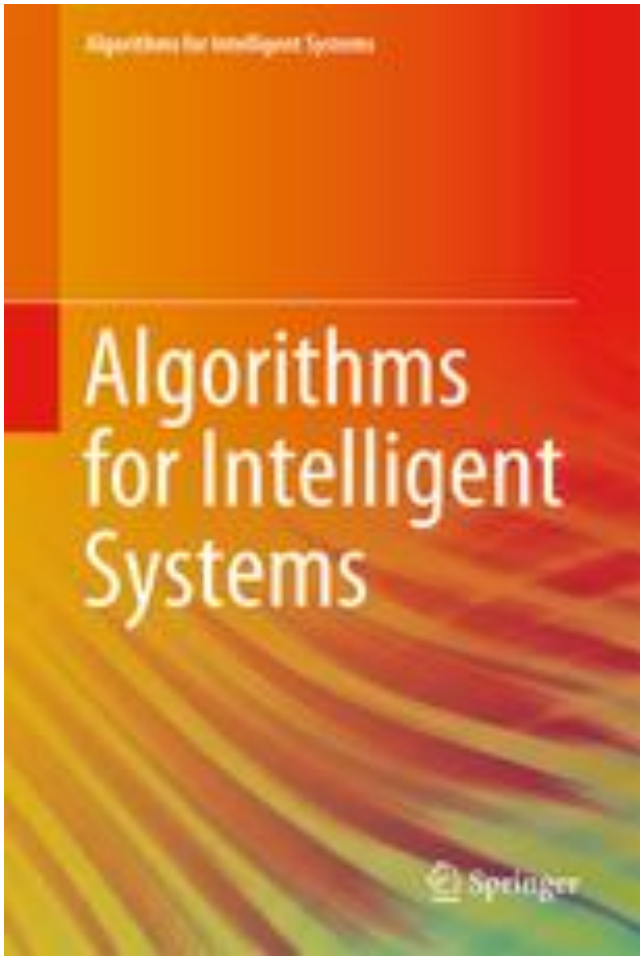
1
0
0

//There is no abandoned solution since L = 6
//If there is an abandoned solution (the solution of which the trial counter value is
//higher than L = 6); generate a new solution randomly to replace with the
//abandoned one.
Cycle = Cycle+1

The same procedure is continued until the termination criterion is attained.

Some Information

Book/Proceedings Proposal Invited



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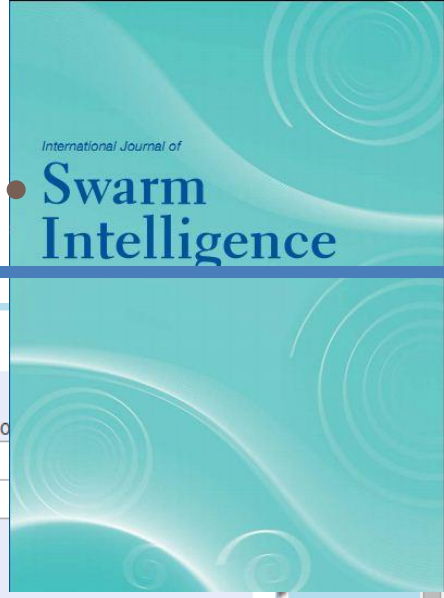

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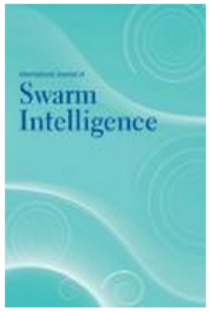

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