Artificial Bee Colony Algorithm

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Outline

Description

What is it?

The Artificial Bee Colony (ABC) algorithm is a swarm-based algorithm inspired by the foraging behavior of honey bees proposed by Karaboga [1]. It aims to optimize multidimensional and multimodal functions.

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- what is foraging?
- what is multimodal?

Many variations

There are many changed versions of the algorithm for specific needs. It all depends on the problem you are willing to solve. The survey in [2] shows different variations and applications.

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- Employed bees: memorize and exploit specific food sources;
- Onlookers: exploit already known good food sources;
- Scouts: search for new food sources around without prior information.

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- Each **coordinate** represents **parameters** of the solution.
- The **nectar amount** of a food source represents its **fitness value**.
- Each **type of bee** represents a **step** of the algorithm.

Pseudocode

```
procedure ABC(population_size, maximum_cycle_number, limit)
    initialize population_size food_sources
    generate random position for food_sources
    while maximum_cycle_number is not met do
        send employed bees
        calculate the probabilities
        send onlookers
        send scouts
        memorize the best food source
    end while
end procedure
```

Employed bees phase

- Each food source will be exploited once. The exploitation process generates modifications in the parameters of the food source, hoping that a better solution will be found.
- If a better food source is found, the old one is forgotten.

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Equation 1

Given the number of food sources F and the dimension of the problem D, each food source f_i will generate a possible new food source v_i following the formula:

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

where i $\in [1, 2, 3, ..., F]$, j $\in [1, 2, 3, ..., D]$, k $\in [1, 2, 3, ..., F]$ and ϕ_{ij} is a random number $\in [-1, 1]$.

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Equation 2

Given the number of food sources F, the probability p_i for a food source i will be calculated by the formula:

$$p_i = \frac{fit_i}{\sum_{n=1}^{F} fit_n}$$

where i $\in [1, 2, 3, ..., F]$.

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- The chosen food sources will be exploited. If a new food source with better fitness is found, the old one is forgotten.

Scouts phase

- If a food source was not changed in a cycle, its trial counter will rise.
- At the end of every cycle, the food source with the biggest trial counter will receive a random solution if its trial counter is bigger than the parameter *limit*.

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Why does it work?

- As said by [3] the ABC algorithm performs different selection process:
  - a global selection process performed by the onlookers;
  - a local selection process performed by onlookers and employed bees;
  - a random selection process performed by scouts.

Why does it work?

- As said by [3] the ABC algorithm performs different selection process:
  - a global selection process performed by the onlookers;
  - a local selection process performed by onlookers and employed bees;
  - a random selection process performed by scouts.
- The employed bees and onlookers are responsible for **the exploitation process** in the search space, while the scouts are responsible for the **exploration process**.

Implementation

- You can find the python code on https://goo.gl/B6tTgv.

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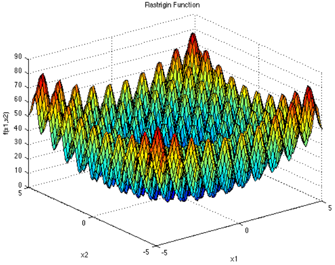
- To validate my implementation, I will test the algorithm with a function from [3] using the same parameters and compare the results.

Rastrigin function

$$f(x_1 \cdots x_n) = 10n + \sum_{i=1}^{n} (x_i^2 - 10cos(2\pi x_i))$$

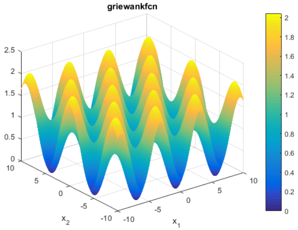
- It is a multimodal function with locations of the minima regularly distributed. The interval is $-15 \leq x_i \leq 15$ and the function has its global minimum at $f(0, \cdots, 0) = 0$.



Griewank function

$$f(x_1 \cdots x_n) = 1 + \frac{1}{4000}\sum_{i=1}^{n} x_i^2 - \prod_{i=1}^{n} cos(\frac{x_i}{\sqrt{i}})$$

- It is a multimodal function with locations of the minima regularly distributed. The function has a interdependence between variables. The interval is $-600 \leq x_i \leq 600$ and the function has its global minimum at $f(0, \cdots, 0) = 0$.



Parameters

- 50% of employed bees, 50% of onlookers, one scout.
- population_size: 125.
- maximum_cycle_number: 500.
- dimension: 10.
- limit: 50.
  - The author did not write about this parameter in [3].
- Each experiment was repeated 30 times.

Results

Table: Comparison of results

	Results from [3]		My results	
	Mean	SD	Mean	SD
Rastrigin	0	0	$1.76 * 10^{-12}$	$2.83367 * 10^{-12}$
Griewank	0.000870	0.002535	0.000142	0.000497

Examples of applications

As showed by [2], the ABC algorithm has already been successfully applied to Search-based Software Engineering problems. Some examples are:

- software test case optimization;
- automated generation of structural tests;
- automated software refactoring;

References

[1] Dervis Karaboga. An idea based on honey bee swarm for numerical optimization. Technical report, 2005.

[2] Dervis Karaboga, Beyza Gorkemli, Celal Ozturk, and Nurhan Karaboga. A comprehensive survey: Artificial bee colony (abc) algorithm and applications. *Artif. Intell. Rev.*, 42(1):21–57, June 2014.

[3] Dervis Karaboga and Bahriye Basturk. A powerful and efficient algorithm for numerical function optimization: Artificial bee colony (abc) algorithm. *J. of Global Optimization*, 39(3):459–471, November 2007.

Thank you for your attention!
https://goo.gl/B6tTgv
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