Artificial Bee Colony Algorithm

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Introduction

- Bonabeau has defined swarm intelligence as

  "any attempt to design algorithms or distributed problem-solving devices inspired by the collective behavior of social insect colonies and other animal societies" [1]

- Term swarm in general refer to any restrained collection of interacting agents or individuals

- Two fundamental concepts self-organization and division of labor, are necessary and sufficient properties to obtain swarm intelligent behavior

Behavior of Honey Bee Swarm

Three essential components of forage selection:

- 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.

- 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 model defines two leading modes of the behavior:
  - recruitment to a nectar source
  - the abandonment of a source.

Exchange of Information among bees

- The exchange of information among bees is the most important occurrence in the formation of collective knowledge.
- The most important part of the hive with respect to exchanging information is the dancing area
- Communication among bees related to the quality of food sources takes place in the dancing area.
- This dance is called a Waggle dance.

- Employed foragers share their information with a probability proportional to the profitability of the food source, and the sharing of this information through waggle dancing is longer in duration.

- An onlooker on the dance floor, decides to employ herself at the most profitable source.

- There is a greater probability of onlookers choosing more profitable sources since more information is circulated about the more profitable sources.

Basic Self Organization Properties

- Positive feedback: As the nectar amount of food sources increases, the number of onlookers visiting them increases, too.
- Negative feedback: The exploitation process of poor food sources is stopped by bees.
- Fluctuations: The scouts carry out a random search process for discovering new food sources.
- Multiple interactions: Bees share their information about food sources with their nest mates on the dance area.

Artificial Bee Colony Algorithm

- Simulates behavior of real bees for solving multidimensional and multimodal optimization problems.
- The colony of artificial bees consists of three groups of bees: employed bees, onlookers and scouts.
- The first half of the colony consists of the employed artificial bees and the second half includes the onlookers.
- The number of employed bees is equal to the number of food sources around the hive.
- The employed bee whose food source has been exhausted by the bees becomes a scout.

ABC Algorithm

Send the scouts onto the initial food sources

REPEAT

- **Send the employed bees onto the food sources and determine their nectar amounts**
- **Calculate the probability value of the sources with which they are preferred by the onlooker bees**
- **Send the onlooker bees onto the food sources and determine their nectar amounts**
- **Stop the exploitation process of the sources exhausted by the bees**
- **Send the scouts into the search area for discovering new food sources, randomly**
- **Memorize the best food source found so far**

UNTIL (requirements are met)

Explanation

- Each cycle of search consists of three steps: moving the employed and onlooker bees onto the food sources and calculating their nectar amounts; and determining the scout bees and directing them onto possible food sources.
- A food source position represents a possible solution to the problem to be optimized.
- The amount of nectar of a food source corresponds to the quality of the solution
- Onlookers are placed on the food sources by using a probability based selection process.

- As the nectar amount of a food source increases, the probability value with which the food source is preferred by onlookers increases, too.

- The scouts are characterized by low search costs and a low average in food source quality.

- The selection is controlled by a control parameter called "limit".

- If a solution representing a food source is not improved by a predetermined number of trials, then that food source is abandoned and the employed bee is converted to a scout.

Control Parameters of ABC Algorithm

- swarmsize
- Limit
- number of onlookers: 50% of the swarm
- number of employed bees: 50% of the swarm
- number of scouts: 1

Exploration vs Exploitation

- Onlookers and employed bees carry out the exploitation process in the search space

- Scouts control the exploration process

Java source Code

```
for(run=0;run<bee.runtime;run++)
  {
     bee.initial();
    bee.MemorizeBestSource();

for (iter=0;iter<bee.maxCycle;iter++)
    {
     bee.SendEmployedBees();
     bee.CalculateProbabilities();
     bee.SendOnlookerBees();
     bee.MemorizeBestSource();
     bee.SendScoutBees();
    }
}
```

Explanation

- bee.initial(): Number of food sources are initialized randomly and fitness of each food source is computed. This task is performed by the initial scout bee and hence supports exploration

- bee.Memorize(): The best food source is memorized by the bee

- bee.SendEmployedBees(): In this function an artificially employed bee generates a random solution that is a mutant of the original solution.

- The formula for producing a candidate solution from the existing is described below:

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

where k: {1,2,….. Number of Employed Bees}

j: {1,2,….D} are randomly chosen index

D: Number of parameters to optimize

k<> i : both are randomly chosen

ϕi,j: random number [-1,+1]

```
solution[param2change]=Foods[i][param2change]+(Foods[i][param2change]-
Foods[neighbour][param2change])*(r-0.5)*2;
```

- After each candidate source position vi,j is produced and then evaluated by the artificial bee, its performance is compared with that of xi,j. If the new food has equal or better nectar than the old source, it is replaced with the old one in the memory. Otherwise, the old one is retained. In other words, a greedy selection mechanism is employed as the selection operation between the old and the current food sources.

- bee.CalculateProbabilities(): An onlooker bee chooses a food source depending on the probability value associated with that food source, *pi,* calculated by:

$$p_i = \frac{\mathrm{fit}_i}{\sum_{n=1}^{\mathrm{SN}} \mathrm{fit}_n},$$

- Bee.SendScoutBees(): The trial parameter is defined for those solutions that are exhausted and not changing. This function determines those food sources and abandons them

Simulation for Rosenbrock function

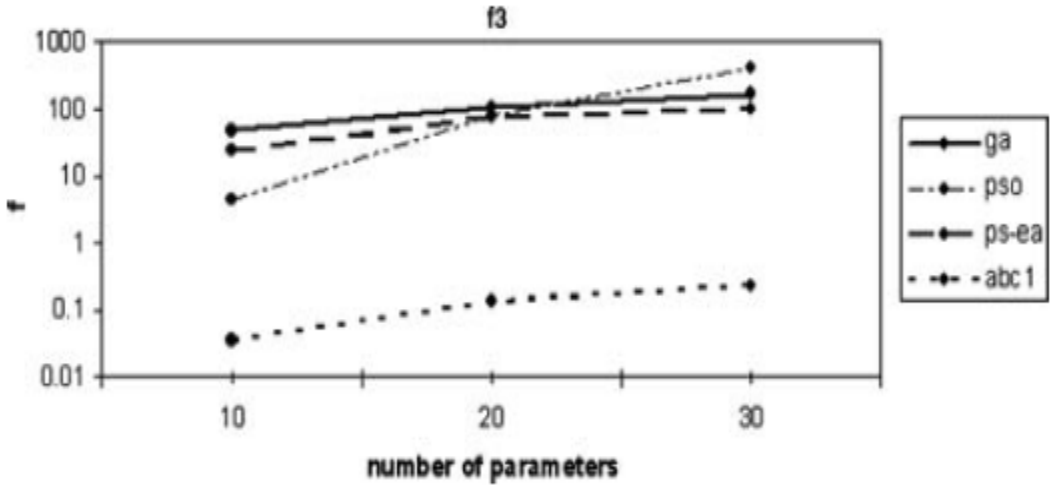

Fig. 3 The mean best values obtained for f_3 by GA, PSO, PS-EA and ABC1 after 500, 750 and 1,000 cycles for dimensions 10, 20 and 30

Conclusion

ABC algorithm in fact employs four different selection processes:

- A global selection process used by the artificial onlooker bees for discovering promising regions as
- A local selection process carried out in a region by the artificial employed bees and the onlookers depending on local information
- A local selection process called greedy selection process carried out by all bees in that if the nectar amount of the candidate source is better than that of the present one, the bee forgets the present one and memorizes the candidate source. Otherwise the bee keeps the present one in the memory.
- A random selection process carried out by scouts.

References

[1] E. Bonabeau, M. Dorigo, G. Theraulaz, “Swarm Intelligence: From Natural to Artificial Systems”, New York, NY: Oxford University Press, 1999.

[2] D. Karaboga , B. Basturk “A powerful and efficient algorithm for numerical function optimization: artificial bee colony (ABC) algorithm, J Glob Optim (2007) 39:459–471

[3] D.Karaboga “An idea based on honey bee swarm for numerical optimization” TR-06, October 2005