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# SWARM INTELLIGENCE ALGORITHMS IN REACTIVE POWER OPTIMIZATION

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## ABSTRACT

Solving multi-objective optimization problem with the desired boundary has been a great deal since few decades. This has paved way for many search algorithms which provides reasonable optimal value convincing running period. Of all the search algorithms, the swarm based algorithms were found promising in obtaining the optimal solution with minimal convergence time. This article presents few of such search algorithms that has been developed from the inspiration honeybee's lifestyle. This could be regarded as intelligent optimization tools. Some searches even uses greedy criterion for attaining the solution if and only if it satisfies the objective function. This article gives the overview of bee's algorithms that includes Artificial Bee Colonization (ABC), Interactive ABC (IABC), Honey Bee Mating Algorithm (HBMA), Improved Honey Bee Mating Algorithm (IHBMA), Chaotic Honey Bee Mating Algorithm (CHBMA) and our study on implementing such algorithms for the optimization of reactive power problem.

Keywords/Index: Bee's algorithm, Reactive power, ABC, IABC, IHBMA, HBMA, CHBMA.

## INTRODUCTION

Most of the social insects are self organized in team work without any supervision on them and the coordination between them is maintained by various interaction methods between them. These interactions are sometimes primitive and sometimes as complex as possible. This collective behavior from the group of social insects is being recognized as Swarm Intelligence (SI) [2] [3]. The agents of SI generally interact locally within their neighbors as well as with their surroundings. Though there are no such rules to be followed by the individual the interaction between them leads them to a global behavior.

## MATERIALS AND METHODS

### 1. ABC

The ABC algorithm is developed by inspecting the behaviors of the real bees on finding food source, which is called the nectar, and sharing the information of food sources to the bees in the nest. In the ABC, the artificial agents are defined and classified into three types, namely, the employed bee, the onlooker bee, and the scout [4] [5]

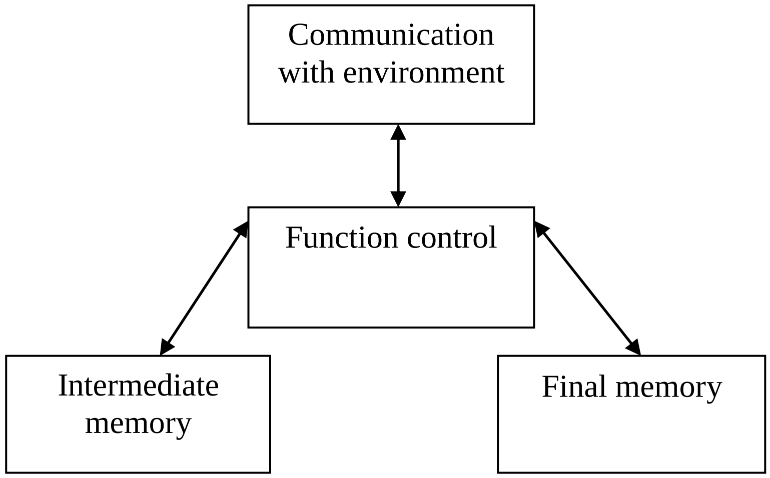


**Fig.1 process cycle of ABC**

Each of them plays different role in the process: the employed bee stays on a food source and provides the neighborhood of the source in its memory; the onlooker gets the information of food sources from the employed bees in the hive and select one of the food source to gather the nectar; and the scout is responsible for finding new food, the new nectar, sources. The process of the ABC algorithm is presented as follows:

Step 1:

Spread some percentage of the populations into the solution space randomly, and then calculate their fitness values, which are called the nectar amounts, where $n_e$ represents the ratio of employed bees to the total population. Once these populations are positioned into the solution space, they are called the employed bees.

Step 2:

Calculate the probability of selecting a food source select a food source to move to by roulette wheel selection for every onlooker bees and then determine the nectar amounts of them.

Step 3:

If the fitness values of the employed bees do not be improved by a continuous iterations, those food sources are abandoned, and these employed bees become the scouts.

Step 4:

Memorize the best fitness value and the position, which are found by the bees.

Step 5:

Check if the amount of the iterations satisfies the termination condition. If the termination condition is satisfied, terminate the program and output the results; otherwise go back to the Step 2.

$$P_i = \frac{f(\theta_i)}{\sum_K^S f(\theta_k)} \qquad (1)$$

where $\theta_i$ denotes the position of the $i^{th}$ employed bee, $S$ represents the number of employed bees, and $P_i$ is the probability of selecting the $i^{th}$ employed bee.

## 2. IABC

In general, the ABC algorithm works well on finding the better solution of the object function. Therefore, it is not strong enough to maximize the exploitation capacity [6]. The Interactive Artificial Bee Colony algorithm is proposed based on the structure of ABC algorithm. By employing the Newtonian law of universal gravitation described in the equation below, the universal gravitations between the onlooker bee and the selected employed bees are exploited.

$$F_{12} = G\frac{m_1 m_2}{r_{21}^2}\widehat{r_{21}} \qquad (2)$$

In the equation, $F_{12}$ denotes the gravitational force heads from the object 1 to the object 2, $G$ is the universal gravitational constant, $m_1$ and $m_2$ are the masses of the objects, $r_{21}^2$ represents the separation between the objects, and $\widehat{r_{21}}$ denotes the unit vector in the equation.

$$\widehat{r_{21}} = \frac{r_2 - r_1}{|r_2 - r_1|} \qquad (3)$$

The mass, 2, is substituted by the fitness value of the randomly selected employed bee [7]. The process of the IABC can be described in 5 steps:

Step 1:

Spread the populations into the solution space randomly, and then calculate their fitness values, which are called the nectar amounts, and calculate the ratio of employed bees to the total population. Once these populations are positioned into the solution space, they are called the employed bees.

Step 2:

Calculate the probability of selecting a food source, select a food source to move to by random program for every onlooker bees and then determine the nectar amounts of them.

Step 3:

If the fitness values of the employed bees do not be improved by a continuous predetermined number of iterations

Step 4:

Memorize the best fitness value and the position, which are found by the bees.

Step 5:

Check if the amount of the iterations satisfies the termination condition. If the termination condition is satisfied, terminate the program and output the results; otherwise go back to the Step 2.

## 3. HBMA

The honey bee community consists of three structurally different forms: the queen, drones and workers [8] [9]. In the original HBMO algorithm a drone mates with a queen probabilistically using an annealing function as follows

$$P_r(D) = \exp\left(-\Delta(F)/V_{queen}(t)\right) \qquad (4)$$

where $P_r(D)$ is the probability of adding the sperm of drone D to the spermatheca of the queen, $\Delta(F)$ is the absolute difference between the fitness of D and the fitness of the queen and $V_{queen}(t)$ is the velocity of the queen at time t. After each transition in space, the queen's velocity decreases according to the following equations:

$$V_{queen}(t+1) = \alpha \times V_{queen}(t) \qquad (5)$$

where $\alpha$ is a positive real parameter called decreasing factor. It controls the amount of speed reduction after each transition and each step. It changes between zero and one.

## 4. IHBMA

In the original HBMO algorithm, the broods are generated by mating between the queen and one drone.

$$X_{brood,j} = X_{queen} + \beta \times (X_{queen} - D_i) \qquad (6)$$

where Di is the $i^{th}$ drone stored in the spermatheca and $\beta \in [0,1]$; is called mating factor. Traditional mating process combines the features of two parents Structures to form two similar offspring's. Its purpose is the maintenance and exchange of queen's place. But this cannot guarantee the convergence to the optimal point and sometimes causes premature convergence to local minima. The utilization of improvements in the breeding process can be useful to escape more easily from local minima compared to the traditional mating.

## 5. CHBMA

Generally, a probabilistic method has a large possibility of exploring the search space freely in the beginning and slowly few valleys while the run is progressed. In order to avoid this shortcoming, we propose a chaotic Improved HBMO (IHBMO) method that combines IHBMO with chaotic local search (CLS)[10]. There are two CLS procedures. In the first CLS method, CLS is based on the logistic equation (CLS1), while the latter CLS is based on the Tent equation (CLS2) To apply the chaotic local search on the IHBMO algorithm, the following steps should be repeated:

Step 1:
Generate an initial chaos population randomly for CLS1
or CLS2
Step 2:
Determine the chaotic variables
Step 3:
Mapping the decision variables
Step 4:
Convert the chaotic variables to the decision variables
Step 5:
Evaluate the new solution with decision variables
Step 6:
Evaluate fitness function for all individuals of CLS1 or CLS2
Step 7:
Replace the best solution among them with one drone Selected randomly
Step 8: Termination criteria.

## 6. HONEY BEE ALGORITHM IN POWER OPTIMIZATION

The problem is formulated as nonlinear optimization involving both the integer and real values. The selection of the solution involves selection from all the possible configurations, and finally the one that incurs the lowest power loss satisfying all the constraints like voltage profile and power requirements is found[1]. The major objective function is,

$$\text{Minimize } f(x) = \sum_{i=1}^{N_a} r_i I_i^2 \qquad (7)$$

The minimization is carried out with the following constraints in consideration:[1]

I. Voltage Magnitude
II. Node current
III. Radial Topology

The voltage magnitude is given by

$$V_{min} \le |V_i| \le V_{max}; \qquad (8)$$

And the branch current is

$$|I_j| \le I_{j\,max}; \qquad (9)$$

In the analysis, power flow and system losses are calculated by the power flow method using the power system analysis toolbox (PSAT 2.1.6) in MATLAB. The algorithm can be expressed as:

$$P_i = P_{i+1} + P_{Li+1} + r_{i,j+1}\frac{P_i^2+Q_i^2}{|v|^2} \qquad (10)$$

$$Q_i = Q_{i+1} + Q_{Li+1} + x_{i,i+1}\frac{P_i^2+Q_i^2}{|v|^2} \qquad (11)$$

Where $P_i$ and $Q_i$ are the active and reactive line power flowing out of the bus i, respectively, the power loss considering the resistance and reactance of the line between buses i and i+1 are denoted by

$$P_{loss}(i, i+1) = r_{i,j+1}\frac{P_i^2+Q_i^2}{|v|^2} \qquad (12)$$

The total system power loss $P_{Total\ loss}$ the sum of power losses of all feeders in the system [1]

$$P_{Total\ loss} = \sum_{i=0}^{n-1} P_{loss}(i, i+1)$$

The ABC is used for this analysis and has been done in both MATLAB and C++ and the results were obtained and it is found promising. Now we are studying on how to relate CHBMA in optimal power flow problems.

Relative comparison:

The attributes and characteristics of above explained algorithms are tabulated as follows,

## RESULTS

The power flow analysis made using the PSAT and the data to be given as the nectar to the algorithm are framed. The data input given to the program includes the p.u unit value of the voltage, phase angle, real and reactive power generations and load requirements. The algorithm deals with the voltage profile thereby

| Name of the Algorithm | Control variable | Time rate | Importance on | Optimal value |
|---|---|---|---|---|
| ACO | Pheromone path | slow | Shortest path | medium |
| PSO | Particle in XY axes | mediu m | Position of particle | fair |
| IPSO | Particle in XY axes | modera te | Velocity of particle | good |
| ABC | Nectar strength | good | Movement of scout | good |
| HBMA | spermatha | fair | Drone quality | good |
| CHBMA | Chaotic local value | good | Drone & local best | better |

indirectly changing the values of real and reactive power [1]. The result obtained from the program run based on the ant colony algorithm is found to be optimal and the convergence rate is found to be promising when compared to that of the particle swarm optimization. The optimal value is obtained from the 14th cycle and the results are as follows.

| Bus | voltage profile |
|---|---|
| 0 | 0.96 |
| 1 | 0.96 |
| 2 | 0.96 |
| 3 | 0.96 |
| 4 | 0.96 |
| 5 | 0.94 |
| 6 | 0.97 |
| 7 | 0.96 |
| 8 | 0.96 |
| 9 | 0.96 |
| 10 | 0.96 |
| 11 | 0.96 |
| 12 | 0.96 |
| 13 | 0.97 |

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## CONCLUSION

Thus the article explains various swarm intelligent algorithms and its pseudo code of working their objective functions and the implementation of the Artificial Bee Colonization on reactive power optimization problem is discussed with the obtained results.

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