Artificial BEE Colony Algorithm, a Comparative Approach for Optimization Algorithm and Application: Survey

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**Abstract** - Artificial Bee Colony(ABC) is nature-inspired meta-heuristic approach, that is exist from the foraging behavior of real honey bees, it’s branch of swarm intelligence due to its simplicity, flexibility and robustness and also have a fewer control parameter, several research in optimization are done using ABC. In this review paper, we provide extensive review of application of ABC; advantages of ABC compare to other optimization algorithm, and hybrid ABC are also highlighted.

**Keywords**: Artificial Bee Colony Algorithm, Nature-Inspired Meta-heuristics, Optimizations, Swarm Intelligence

I. INTRODUCTION

The last few decades have witnessed the introduction of several optimization algorithms developed based on nature-inspired ideas. Some examples of optimization algorithms include ant colony optimization [2], evolutionary algorithm [3], particle swarm optimization [2], Firefly optimization [4] etc. Most of these algorithms are meta-heuristic based search techniques and generally referred to as multipurpose optimization algorithms because of their applicability to a wide range of problems. In a similar context, Artificial Bee Colony algorithm (ABC) The last few decades have witnessed the introduction of several optimization was initially introduced by Karaboga in 2005 as a technical report for numerical optimization problems [5]. Its development was motivated by Simulating the intelligent foraging behaviour of real honey bees in their colony and its performance was initially measured using benchmark optimization function.

Major advantages of ABC holdover other optimization Algorithm
A. Simplicity, flexibility and robustness [6].
B. Use of fewer control parameter compare to other optimization algorithm [7] mathematical operation.
C. Easily hybridization with other optimization algorithm [6].
D. Simple and easy implementation with basic mathematical operation.

Drawback of ABC compare to other hybrid version of ABC Algorithm
A. Theoretical analysis is difficult.
B. ABC regarding its solution search equation, this is good at exploration, but poor at Exploitation [8] Mainly use of this optimization algorithm are Maximal diverse grouping problem[9], Scheduling[10,11], two dimensional protein folding structure[12], Economic dispatch[13] and many other and also we used variant version of ABC for this application. Optimization problem can be classified in two types of problem A. Constrained problem and B. Unconstrained problem [14]. ABC is solved this two types of problem.

The main objective of this current paper is to present an extensive summary of development of ABC and variants of ABC and its application.

II. HOW ABC WORK?

Inspired by the intelligent foraging behavior of honey bee Swarms, the ABC algorithm was introduced to handle unconstrained benchmark optimization functions [14], similar to other well-known meta-heuristic algorithms. An extended Version of the ABC algorithm was then offered to handle constrained optimization problems.

In ABC has a mainly three types of group in bees
A. Employed bees
B. Onlooker bees
C. Scout bees

All three group’s working are different and pictorial representation are define in fig.1

First initialize population that is population of i solutions (i = 1, 2, … E_b) where i signifies the size of population and E_b is the number of employed bees equal to colony sine that is divided in two parts equally employed bees and onlooker bees After initialization, the population of the positions is subjected to repeated cycles of the search processes for the employed, Onlooker, and scout bees (cycle = 1, 2 … MCN), where MCN is the maximum cycle number of the search process. Here, theoretical define working of this three phase

- **Algorithmic structure of ABC:**
  - Initialization Phase
  - Employed Bees Phase
  - Onlooker Bees Phase
  - Scout Bees Phase
Memorize the best solution achieved so far UNTIL (Cycle = Maximum Cycle Number)

Employed bees
Artificial employed bees search for new food sources having more nectar within the neighborhood of the food source in the memory. They find their fitness value for that food sources, after producing new food sources, greedy selection are applied between it’s and it’s parent.

After employed bees share their food source information with onlooker bees this are waiting in hive by dancing on the dancing area.

Onlooker bees
Artificial onlooker bees probabilistically choose their food sources depending on the information provided by the employed bees. For this purpose fitness base selection technique can be used such as roulette wheel, tournament selection etc.

After food sources for an onlooker bee is probabilistically chosen a neighbourhood sources is determined and its fitness value is computed, as an employed bee phase a greedy selection is applied between two sources.

Probability pi of selecting a food sources by onlooker bees

\[ P_i = \frac{fitness_i}{\sum_{i=1}^{E} fitness_i} \]  

(1)

Where, fitness\textsubscript{i} is the fitness value of a solution i, and E is the total number of food-source positions or, in other words, half of the colony size[15].

Mathematical expression of onlooker bees

\[ X^{new}_i = X^g_i + u (X^{best}_i - X^g_i) \]  

(2)

Scout bees Employed bee whose ith solution can not improved through a predetermined no. of trials, called “limit” now employed bee become scout bee and its solution abandoned. Scout starts search for randomly, hence those source which are initially poor have made poor by exploitation are abandoned, and negative feedback behaviour arises to balance the positive feedback.

\[ X^{new}_i = \min X^g_i + u (\max X^g_i - \min X^g_i) \]  

(3)

Here, u is a random number and its range is between [-1, 1] and ABC has three parameter like 1. Population size 2. Limit and 3. Maximum Cycle Number.

III. ABC OPTIMIZATION

Since its first introduction in 2005, ABC continues to attract the interest of investigators from diverse disciplines across the globe [1]. Furthermore ABC result re compared with other optimization algorithm from all survey we found ABC is best but ABC has a one limitation that is it is good at exploration but poor at exploitation. For this limitation is removed by using modified version of ABC [15].

Now, we see the comparison of different optimization algorithm and how ABC is more successful than other optimization algorithm

A. Comparative Analysis

Karaboga and Basturk in [1] extended the ABC algorithm to handle constrained optimization problems. A set of 13 benchmark optimization problems was examined, and the results were compared with Differential Evolution (DE) and PSO algorithms. Optimization functions, with the dimension of each function varying from 10 to 30.

Now, ABC is give efficient result than ACO(ant colony optimization) and PSO(particle swarm optimization) because of ACO is time to convergence is uncertain and sequence of random decision(not independent) and PSO is easily suffer from the partial optimization and it doesn’t work out of scattering optimization[2]. But all those disadvantages are removed by ABC.
The particle swarm optimization algorithm was first described in 1995 by James Kennedy and Russell C. Eberhart [2]. In fig.(2) and fig.(3) are link of PSO that are derived based on a communication structure or social network is also defined, assigning solution to its neighbors for that each individual are interact with each other.

ACS mean ACO was proposed by Dorigo et al. (Dorigo and Gambardella, 1997) as a new heuristic to solve combinatorial optimization problems. Based on this ant chain, ant colony algorithm is defined, and its work mainly based on amount of pheromones. And find best optimum cost path.

The protein-folding problem is a challenging biochemistry energy minimization task which can be solved experimentally or computationally. Experimental results are accurate but it's very expensive and time consuming. Due to these limitations, Scientists solved this problem as an optimization problem. The authors of [12] utilized the ABC algorithm to identify the Protein structure, and compared the results to other techniques.

The authors of utilized the ABC algorithm to train feed-forward neural networks. Three tests were considered: the Exclusive OR, 3-Bit Parity and 4-Bit Encoder-Decoder problems. The solutions obtained by the proposed algorithm were compared with those attained using the GA and Back Propagation (BP) techniques.

For the scheduling ABC give better result than other algorithm like HGA, HDPSO [10].

B. Modified Version

Modified version of ABC was proposed in [1]. Modified ABC are used for real parameter optimization in that control parameter introduced like modified rate and scaling factor in that replacing the random initialization with the opposition based population initialization can get better initial solutions and then accelerate convergence speed.

Interactive ABC is used for numerical optimization universal gravitation force is used for change the movement of onlooker bees.

In that used force gravitation equation instead of random number. Now here define gravitation force equation

\[
\text{Fgrav} = k_s \left( f(x) \ast (f(x)) \right) \left| \theta_{ij} - \theta_{ij} \right|^2 + \left( \left| \theta_{ij} - \theta_{ij} \right| \right) \left( \left| \theta_{ij} - \theta_{ij} \right| \right)
\]

Discrete ABC is enhancing the local search. The initial population with definite diversity and quality were generated with an efficient initialization method, which was based on the Earliest Due Date (EDD), the smallest slack time on the last machine (LSL) and the smallest Overall Slack Time (OSL) rules. Furthermore, neighboring solutions (food sources) were produced using approach based on insert and swap operators, to enable the DABC algorithm to work on discrete/combinatorial spaces, Mainly used in scheduling purpose [1].

Distributed ABC and Parallel ABC, in distributed entire colony are distributed into sub group communicating using message passing technique. That improves the result and computing time compare to sequential ABC algorithm.

A parallel ABC for security constrained economic dispatch using shared memory model, not only reduced execution time but also improve the quality of solution.

MO-ABC (multi-objective ABC) is used for solve a real-world frequency assignment problem. To determine the direction of flight of a solution, this used external archive strategy to

Preserve non-dominated solution vectors. In FAP minimized two conflict object

1. Separation cost and 2. Interference cost

Mimetic ABC is incorporated Deb’s rule in the selection of food source employed and onlooker bees. Used for large scale global optimization. Four exploration stages are identified: 1.stochastic long-distance, 2.stochastic moderate-distance, 3.deterministic short-distance, and 4. random long-distance explorations.

Using MABC getting optimal result that are comparable with the results of DECC-G, DECC-G*, and MLCC algorithm.

C. Various Application

Many applications of ABC algorithm to real world and benchmark optimization problems have been reported, and in much publication ABC algorithm are compared with other optimization algorithm and find out that result is best using ABC algorithm. Here some application is also discussed in detail likewise scheduling, maximally diverse grouping problem (cluster), two dimensional protein folding structure (bioinformatics) and wireless application.

• Scheduling Application

Discrete ABC For lot-streaming flow shop scheduling problem and resources constrained project scheduling best sequence of events to be assigned to limited resources and minimize total production cost and execution time.

When assigning job to particular machine in lot-streaming flow shop scheduling problem, so assigning job in way that finally minimize job completion time [10, 11].

The performance of ABC was successful on real world problems involving machines, large number of parts and production lines.

• Clustering And Mining Application

In that main clustering application is maximally diverse grouping problem [9], define m-disjoint group with n-elements. And find-out dissimilarity using Euclidian distance so, mainly focus on clustering split data into cluster and if
euclidian distance range is high than put data into different cluster and if it is low than put in one cluster.

ABC is also utilizing in sensor deployment problem, this was modeled as a data clustering problem and the centric of each cluster represented the position of a sensor node to be deployed [1].

And ABC is also used for data collection path planning in sensor network and for that define cluster of the sensor. So, robot are there and collect the data from the sensor node in a optimize way.

In mining used for classification of data in neural network and also used for prediction from the past data. And in SVM (support vector Machine) ABC is used for kernel parameter optimization [17].

- **Bioinformatics Application**
  
  In the field of computational biology and bioinformatics, ABC was utilized for protein structure prediction, using the three-dimensional hydrophobic polar model with side-chains [1]. And also ABC used for improving two dimensional protein folding simulation [11], ABC algorithm can be applied on the hydrophobic-hydrophilic lattice model. Using ABC is that chains with different lengths showed that the ABC significantly, saves the large amount of energy. In three dimensional hydrophobic polar model, Two parallel approaches similar to master-slave and hybrid-hierarchical relations were implemented by the authors. In master slave process model is centralize system in that one master and so many slave master is assign task to the slave and find optimal solution.

- **Wireless Application**
  
  ABC is also used in wireless network field, a new Multi-objective ABC algorithm to solve a real-world frequency assignment problem. This approach is able to obtain reasonable frequency plans when solving a real-world FAP. Two conflict object are minimized

1. Separation cost and
2. Interference cost

Also used in wireless sensor network for collection of data from the different node in optimize way using ABC algorithm. And used in wimax network planning problem in that how one BS (base station) can cover maximum number of SS (subscriber station) [16].

<table>
<thead>
<tr>
<th>Problem</th>
<th>Method Name</th>
<th>Benefits</th>
<th>Drawbacks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reliability</td>
<td>ABC</td>
<td>Find optimal result of maximally diverse</td>
<td>Use crossover operator</td>
</tr>
<tr>
<td>Redundancy, MDGP</td>
<td></td>
<td>grouping and redundant component in less time</td>
<td></td>
</tr>
</tbody>
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Other application like ABC used in software estimation cost, Forecasting stock markets using wavelet transforms and recurrent neural networks: An integrated system based on ABC algorithm. In neural network application also used ABC, for mainly classification and predication. And also optimize the parameter of neural network like connection between two neurons, architecture and transfer function output is optimizing using ABC [18].

**CONCLUSION AND FUTURE SCOPE**

The aim of this paper is to overview the state-of-the-art research on the ABC algorithm. At last we conclude that In contrast, the ABC algorithm has only two parameters (CS and MCN) to be adjusted. Therefore, the updating of the two parameters towards the most effective values has a higher likelihood of success than other competing meta-heuristic algorithms. Find out ABC and its variants to solve diverse set of problem, but we conclude that compare to ABC its variants give better result of any problem. And we also describe ABC application and how ABC is better than other optimization algorithm.

As a future work, I will try to implement synthesis of ANN using MABC.

**REFERENCES**


