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A Comprehensive Study of Artificial Bee Colony (ABC) Algorithms and Its Applications

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Abstract - *Artificial bee colony algorithm could be a good optimization algorithm supported the bee's acquisition model. This review proposed a comprehensive study of various artificial bee colony (ABC) algorithms and its Applications. Finally, this paper compares various bees' algorithm with testing on complex function optimization problems. The results of various algorithms shown that the algorithm proved to be effective to improve the search performance, particularly for high dimensional advanced optimization problem.*

Key Words: Artificial Bee Colony, Co-operative particle swarm optimization, Data Driven Artificial Bee Colony, Function Optimization, Global Artificial Bee Colony Search, Improved Artificial Bee Colony, Particle swarm optimization.

1. INTRODUCTION

The last few decades have witnessed the introduction of several optimization algorithms developed based on nature-inspired ideas. Some examples of such algorithms include ant colony optimization, evolutionary algorithm, particle swarm optimization, Harmony search.

Artificial Bee Colony algorithm (ABC) was initially published by Karaboga in 2005 as a technical report for numerical optimization problems. ABC is a new swarm intelligence algorithm proposed by Karaboga in 2005, which is inspired by the behavior of honey bees since the development of ABC, it has been applied to solve different kinds of problems. Artificial bee colony (ABC) algorithm is a recently proposed optimization technique which simulates the intelligent foraging behavior of honey bees. The major advantages which ABC holds over other optimization algorithms include its:

- Simplicity, flexibility and robustness
- Use of fewer control parameters compared to many other search techniques
- Ease of hybridization with other optimization algorithms.
- Ability to handle the objective cost with stochastic nature [36].
- Ease of implementation with basic mathematical and logical operations. Particle swarm optimization

Particle swarm optimization (PSO) is a computational method that optimizes a problem by iteratively trying to improve a candidate solution with regard to a given measure of quality. ABC is based on PSO [37].

2. GROWTH OF ABC ALGORITHM

After the invention of ABC by Karaboga (2005), the first conference paper introducing ABC was published in 2006 (Basturk and Karaboga 2006). The first journal article describing ABC and evaluating its performance was presented by Karaboga and Basturk (2007b), in which the performance of ABC was compared to GA, PSO and particle swarm inspired Evolutionary algorithm. In 2008, the second article presenting a performance evaluation of ABC was published by Karaboga and Basturk (2008). In 2009, a public domain web-site (http://mf.erciyes.edu.tr/abc) dedicated to ABC was constructed. There are several source codes, written in different programming languages, of ABC and many publications about the Modifications to ABC and their applications are presented in the website. The main algorithm of ABC is relatively simple and its implementation is, therefore, straightforward for solving optimization problems and ABC has been found to be very effective in the studies above, being able to produce very good results at a low computational cost. Therefore, after these initial publications many studies have been carried out on ABC.

3. How ABC algorithm works?

The ABC was first proposed to solve numerical optimization problems by Karaboga [38]. ABC consists of employed and unemployed foragers, and food sources. The ABC consists of three groups of artificial bees: employed foragers, onlookers and scouts. The employed bees comprise the first half of the colony whereas the second half consists of the onlookers. In the basic ABC [38], there are 3 kinds of bees: employed, onlooker, and scout bees.

3.1 Phases of ABC

It generally consists of four phases.

1. Initialization of ABC. Determine the number of artificial bees. 50% are employed bees and 50% are onlooker's

bees. Generate the random initial candidate solutions for employed bees using equation. [38] Determine the limit value.

2. Employed bee phase for all employed bees Generate new candidate solution using equation. [6] Calculate the fitness value of the new solution using Equation. [38] If fitness of new candidate solution is better than the existing solution replace the older solution. Calculate the probability for each individual.
3. Onlooker bee phase. For all onlooker bees Select an employed bee using roulette wheel. Produce new candidate solution. Compute fitness of individual. If fitness of new candidate solution is better than the existing solution replace the older solution.
4. Scout bee phase if any food source exhausted then replace it by randomly generated solution by scout memorize the best solution. Until (stopping criteria is not met).

3.2 Three type of Bees in ABC

1. Employed bees
2. Onlooker bees, and
3. Scouts.

Employed and onlooker bees perform the exploitation search.

Scouts carry out the exploration search.

3.3 ABC employs four different selection processes

1. A global selection process used by onlookers.
2. A local selection process carried out in a region by employed and onlooker bees.
3. A greedy selection process used by all bees.
4. A random selection process used by scouts.

3.4 Steps of ABC algorithm

- Step 1: Initialize by picking k random Employed bees from data.
- Step 2: Send Scout bees and test against Employed bees (replace if better than Employed is found).
- Step 3: Send Onlooker bees to Employed.
- Step 4: Test Onlooker bees against Employed (replace if better than Employed is found).
- Step 5: Reduce the radius of Onlooker bees.
- Step 6: Repeat steps 2 to 5 for a given number of iterations.

4. Application of ABC

Applications of Artificial Bee Colony are as follow:

1. Travel Salesmen Problem

This problem belongs to the category of NP-Complete issues . ABC finds higher resolution than GA and alternative ABC is wide used for optimization.

2. Graph Coloring

This application has been done mistreatment artificial bee colony (ABC) optimization algorithm rule. In Graph coloring no two adjacent edges having same color. This can be finding by mistreatment ABC with higher result than alternative algorithm rule.

3. Bioinformatics application

Within the field of Bioinformatics ABC leads to optimizing the polymer sequencing problem with higher result as compared to alternative algorithms.

4. Image process Applications

ABC has its application to image process. Many troublesome issues exist in pattern recognition and image process analysis areas. ABC optimization works higher and optimized the pattern recognition problem. Thus, it's wide used for image process.

5. Benchmarking optimization

Varied operate exits which may be optimized mistreatment ABC algorithmic rule.

5. Review of Literature

Zeynep Gergin et al. [1], [2019], recommended an Artificial Bee Colony (ABC) based mostly cluster algorithmic program for finding continuous multiple facility location issues. Once applying alphabet based mostly cluster algorithmic program on check knowledge, a real-world facility location problem is resolved for characteristic tending waste disposal facility locations for city Municipality. Alphabet based mostly cluster is performed for various variety of clusters predefined by city Metropolitan Municipality. On the opposite hand, the multiple facility location issues the planned cluster algorithmic program deals with aimed to seek out website locations for tending wastes.

Shouna Wang et al. [2], [2018], recommended the artificial bee colony (ABC) algorithmic program has the matter of slow convergence and will be at bay into native optimum. The strategy of dynamic segmentation divides the colony into multiple sub-species, and therefore the species communicate with one another victimization the co-evolution strategy. The MABC algorithmic program uses dynamic segmentation of the swarm and a co-evolution strategy. So as to check the performance of the algorithmic program, they use the MABC algorithm.

Zeeshan Danish et al. [3], [2019], recommended a changed variety of ABCs, i.e. global artificial bee colony search algorithmic program (GABCS) is applied to information cluster. In GABCS the modification is thanks to the very fact that practiced bees will use past info of amount of food and position to regulate their movements during a search house. Thanks to this truth, answer search equations of the canonical ABCs square measure changed in GABCS and applied to a few celebrated real datasets during this work i.e. iris, thyroid, wine, accessed from the UCI info for the aim of knowledge cluster and results were compared with few alternative expressed algorithms like K-NM-PSO, TS, ACO, GA, SA and ABC.

Muhammad Umer Farooq et al. [4], [2019], recommended modern-day industries try to get long-run supplier integrations (SI) with doubtless stronger supplier teams, to attain quick and reliable production. A framework was developed that consists of 3 layers of professional opinions, supplier necessities, and multi-objective bee colony improvement. The method of choosing vendors, whereas at the same time considering the aspects of random factors, multiple criteria, and with efficiency reaching best solutions to enhance the SI.

Maricela Brav et al. [5], [2019], suggested web services cluster is that the task of extracting and choosing the options from a set of web services and forming teams of closely connected services. In recent years, strategies impressed naturally victimization biological analogies are custom-made for cluster issues, among that genetic algorithm, organic process ways, and algorithms that imitate the behavior of some animal species are enforced. The implementation of novel and economical algorithms for web services cluster has relevancy for the organization of service repositories on the net.

Wan-Li Xiang et al. [6], [2019], recommended Improved Artificial bee colony (IABC) algorithmic program as a result of ABCs algorithmic program exploitation ability is comparatively poor. Additionally, a mechanism of frequency of perturbation is used to boost the dimensions of knowledge sharing between a current vector and a guided vector for every witness bee. The two guided vectors square measure chosen with a chance betting on the magnitude relation of fitness info of a current vector thereto of the global-best vector. To unravel the matter, they propose a unique combinatorial search strategy, whose guided vectors are often freely switched between a random vector and therefore the international best vector. At identical time, a random vector is helpful to manage the improved exploitation ability.

MeiZhang et al. [7], [2019],author proposed To balance the exploration and exploitation and to boost the convergence rate of an artificial bee colony (ABC) algorithmic program, the thrust of victimization extra information throughout looking method is studied during this paper, associate degreed an improved ABCs algorithmic program with data-driven improvement (DDABC) is planned.

Changsheng Zhanga et al. [8], [2010] author proposed this algorithm has been tested on several well-known real datasets and compared with other popular heuristics algorithm in clustering, such as GA, SA, TS, ACO and the recently proposed K–NM–PSO algorithm. In suggested an artificial bee colony clustering algorithm is presented to optimally partition N objects into K clusters.

Wenping Zou et al. [9], [2010] suggested First the CABC algorithm is used for optimizing six widely used benchmark functions and the comparative results produced by ABC, Particle Swarm Optimization (PSO), and its cooperative version (CPSO) are studied. Clustering is a popular data analysis and data mining technique; therefore, the CABC could be used for solving clustering problems. The performance of CABC algorithm is compared with PSO, CPSO, and ABC algorithms on clustering problems. In suggested an extended ABC algorithm, namely, the Cooperative Article Bee Colony (CABC), which significantly improves the original ABC in solving complex optimization problems.

Dervis Karaboga et al. [10], [2011] suggested ABC is used for data clustering on benchmark problems and the performance of ABC algorithm is compared with Particle Swarm Optimization (PSO) algorithm and other nine classification techniques from the literature. In suggested Artificial Bee Colony (ABC) algorithm which is one of the most recently introduced optimization algorithms simulates the intelligent foraging behavior of a honey bee swarm.

J. Senthilnath et al. [11], [2011] recommended Clustering is a popular data analysis technique to identify homogeneous groups of objects based on the values of their attributes. The FA is used for clustering on benchmark problems and the performance of the FA is compared with other two nature inspired techniques Artificial Bee Colony (ABC), Particle Swarm Optimization (PSO).

Chunhua Ju et al. [12], [2013] suggested A novel collaborative filtering recommendation approach based on K-means clustering algorithm. In suggested although there are many good collaborative recommendation methods, it is still a challenge to increase the accuracy and diversity of these methods to fulfil users' preferences. The process of clustering use artificial bee colony (ABC) algorithm to overcome the local optimal problem caused by K-means.

Yannis Marinakiset al. [13], [2009] recommended the proposed algorithm is a two-phase algorithm which combines an artificial bee colony optimization algorithm for the solution of the feature selection problem and a GRASP algorithm for the solution of the clustering problem. The performance of the algorithm is compared with other popular Meta heuristic methods like classic genetic algorithms, tabu search, GRASP, ant colony optimization, particle swarm optimization and honey bees mating optimization algorithm. In suggested a new hybrid

algorithm, which is based on the concepts of the artificial bee colony (ABC) and greedy randomized adaptive search procedure (GRASP), for optimally clustering N objects into K clusters.

Celal Ozturk et al. [14], [2015]suggested the prevalence of the planned algorithm is in contestable by examination it with the essential separate artificial bee colony, binary particle swarm improvement, genetic algorithm in dynamic (automatic) cluster, within which the amount of clusters is set mechanically i.e. it doesn't got to be per distinction to the classical techniques. one in every of the foremost well-known binary (discrete) versions of the artificial bee colony algorithm is that the similarity lives primarily based separate artificial bee colony, that was initial planned to subsume the uncapacited facility location (UFLP) problem. The applied mechanism for generating new solutions regarding to the data of similarity between the solutions solely think about one similarity case i.e. it doesn't handle all similarity cases. To hide this issue, new answer generation mechanism of the separate artificial bee colony is increased victimization all similarity cases through the genetically impressed parts.

Ehsan Amiri et al. [15], [2018] recommended the D is ABC could be a new edition of artificial bee colony (ABC) that initial introduced to arranged the uncapacitated facility location problem (UFLP) and improved by the economical genetic choice to resolve dynamic cluster problem. During this analysis, they have a tendency to planned innovative fuzzy technique with improved separate artificial bee colony (ID is ABC) for information cluster known as FID is ABC. Information cluster could be a technique of partitioning information into totally different teams consistent to some similarity or difference live.

Yu Xue et al. [16], [2018] they propose a self-adaptive ABC algorithm supported world best candidate (SABC-GB) for global improvement. The results demonstrate that SABC-GB is superior to the opposite algorithms for determination complicated improvement issues. The artificial bee colony (ABC) algorithm is Associate in intelligent swarm algorithm for world improvement issues. However, the answer search equation utilized in ABC is low, and also the strategy for generating candidate solutions ends up in sensible exploration ability however poor exploitation performance. Besides, to validate the practicability of SABC-GB in real-world application, they have a tendency to demonstrate its application to a true cluster problem supported the K-means technique. Previous studies have shown that the ABC algorithm is economical, effective, and sturdy improvement technique.

Farzaneh Zabihi et al. [17], [2018] suggested Fitness analysis could be a pricey and time overwhelming method in cluster problem, however utilizing the memory mechanism has slashed the amount of fitness evaluations considerably and accelerated the improvement method by estimating the fitness worth of solutions rather than scheming actual fitness values. During this paper, a unique variant of Artificial Bee Colony (ABC) algorithm known as History-driven Artificial Bee Colony (Hd-ABC) is planned to boost the ABC's performance by applying a memory mechanism. Each the experimental and applied mathematics result show that the planned formula outperforms the first ABC, its variants and also the alternative state-of-art cluster algorithms; and also, the simulations indicate terribly promising ends up in terms of answer quality.

S. Sudhakarllango et al. [18],[2018]suggested Associate in Nursing experimental result reveals that the planned ABC theme reduces the execution time and classification error for choosing optimum clusters. In concert of the main issues is that the time taken for death penalty the standard formula is larger which it's terribly troublesome for process great deal of knowledge. The most objective of planned Artificial Bee Colony (ABC) approach is to reduce the execution time and to optimize the simplest cluster for the varied sizes of the dataset. The result's ascertained for numerous fitness and likelihood worth that is obtained from the used and also the witness section of ABC algorithm from that the more calibrations of classification error proportion is completed. The planned ABC algorithm simulates the behavior of real bees for determination numerical improvement issues significantly in cluster. The planned ABC formula is enforced in Hadoop setting victimization plotter and reducer programming.

Reza Mikaeil et al. [19], [2018] recommended eight totally different rocks from open pit mines and road slopes were classified into four separate clusters in line with physical and mechanical properties of rock including uniaxial compressive strength, mean Mohs hardness, Young modulus and Schimazek's F-abrasivity.

Yugal Kumar et al. [20], [2017] suggested Clustering has proved its potentiality in various fields such as bioinformatics, pattern recognition, image processing and many more. In this paper, a two-step artificial bee colony algorithm is proposed for efficient data clustering. In two-step ABC algorithm, the initial positions of food sources are identified using the K-means algorithm instead of random initialization.

Celal Ozturk et al. [21], [2015] recommended a new objective function is proposed for image clustering and is applied with the artificial bee colony algorithm, the particle swarm optimization algorithm and the genetic algorithm. The simulated results show that the ABC-based image clustering method with the improved objective function obtains well-distinguished clusters.

Selim Dilmac et al. [22], [2015] suggested electrocardiogram is the most commonly used tool for the diagnosis of cardiologic diseases. In order to help cardiologists to diagnose the arrhythmias automatically, new methods for automated, computer aided ECG analysis are being developed. In this paper, a Modified Artificial Bee Colony algorithm for ECG heart beat classification is introduced. It is

applied to ECG data set which is obtained from MITBIH database and the result of MABC is compared with seventeen other classifier's accuracy. In this study, in order to find higher distinctive features, a detailed analysis has been done on time domain features. By using the right features in MABC algorithm, high classification success rate is obtained. Other methods generally have high classification accuracy on examined data set, but they have relatively low or even poor sensitivities for some beat types. Different data sets, unbalanced sample numbers in different classes have effect on classification result.

Neeraja Menon et al. [23], [2015] suggested a fast MRI Brain Image segmentation method based on Artificial Bee Colony (ABC) algorithm and Fuzzy-C Means (FCM) algorithm. In order to get an efficient fitness function for ABC algorithm the original image is decomposed by discrete wavelet transforms. The FCM algorithm is used for clustering the segmented image which helps to identify the brain tumor.

Emrah Hancer et al. [24],[2015] recommended the performance analysis of the proposed algorithm is demonstrated by comparing it with some well-known variants of the particle swarm optimization (PSO) and ABC algorithms, including standard binary PSO, new velocity based binary PSO, quantum inspired binary PSO, discrete ABC, modification rate based ABC, angle modulated ABC, and genetic algorithms on 10 benchmark datasets. This paper proposes a binary artificial bee colony (ABC) algorithm for the feature selection problems, which is developed by integrating evolutionary based similarity search mechanisms into an existing binary ABC variant.

Celal Ozturk et al. [25], [2015] suggested Integrated to the neighborhood searching mechanism of the basic ABC algorithm, the modification comprises four stages:

1. In neighborhood of a (current) food source, randomly select two food sources from population and generate a solution including zeros (Zero) outside the population;
2. Apply two-point crossover operator between the current, two neighborhood, global best and Zero food sources to create children food sources;
3. Apply swap operator to the children food sources to generate grandchildren food sources;
4. Select the best food source as a neighborhood food source of the current solution among the children and grandchildren food sources.

Manijeh Reisiet al. [26], [2016] author proposed a feature weighting based artificial bee colony (FWABC) algorithm for data clustering. The performance of the proposed method has been tested on various datasets and compared to well-known and state-of-the-art methods; the reported results show that the proposed method gives better performance to other methods.

Abobakr Khalil Alshamiri et al. [27], [2016] author proposed a method that builds on ELM projection of input data into a high-dimensional feature space and followed by unsupervised clustering using artificial bee colony (ABC) algorithm. While ELM projection facilitates separability of clusters, a meta-heuristic technique such as ABC algorithm overcomes problems of dependence on initialization of cluster centers and convergence to local minima suffered by conventional algorithms such as K-means.

Kusum Kumari Bharti et al. [28], [2016] author proposed the obtained results are compared with the ABC, a recent variant of the ABC namely gbest-guided ABC, a variant of the proposed methodology namely chaotic artificial bee colony, memetic ABC, and conventional clustering algorithm K-means. They use artificial bee colony algorithm (ABC) to select appropriate cluster centers for creating clusters of the text documents. The ABC is a population-based nature-inspired algorithm, which simulates intelligent foraging behavior of the real honey bees and has been shown effective in solving many search and optimization problems. They improve search equation of the ABC and embed two local search paradigms namely chaotic local search and gradient search in the basic ABC to improve its exploitation capability.

Anan Banharnsakun [29], [2017] recommended The ABC is implemented based on the MapReduce model in the Hadoop framework and utilized to optimize the assignment of the large data instances to clusters with the objective of minimizing the sum of the squared Euclidean distance between each data instance and the centroid of the cluster to which it belongs. The experimental results demonstrate that our proposed algorithm is well-suited for dealing with massive amounts of data, while the quality level of the clustering results is still maintained.

Shin Siang Choong et al. [30], [2019] author proposed the Artificial Bee Colony (ABC) algorithm is a swarm intelligence approach which has initially been proposed to solve optimization of mathematical test functions with a unique neighborhood search mechanism. In this paper, a hyper-heuristic method, namely a Modified Choice Function (MCF), is applied such that it can regulate the selection of the neighborhood search heuristics adopted by the employed and onlooker bees automatically. In order to tackle combinatorial discrete optimization problems, the employed and onlooker bees need to be equipped with problem-specific perturbative heuristics. To demonstrate the effectiveness of the proposed model, 64 Traveling Salesman Problem (TSP) instances available in TSPLIB are evaluated. The Lin-Kernighan (LK) local search strategy is integrated to improve the performance of the proposed model.

D. Naga Ravi Kiran et al. [31], [2018] suggested Wireless sensor network (WSN) brings an innovative model with embedded system with restrictions of computing ability, intercommunication, storage capacity, and energy resource which is applied for a high range of applications in the

situations when constructing the network based on conventional infrastructure is not feasible. Rule selection methods combine different rules from fuzzy rule set to decrease the rules while maintaining the performance of the system. The rules that decrease the performance of the system are removed, to get a fuzzy rule set with improved performance.

Bilal Saoud [32], [2018] author proposed the modularity function to measure the strength of the community structure found by our method, which gives us an objective metric for choosing the number of communities (clusters) into which a network should be divided. Our method based on bee colony to split a network into two networks (clusters) which maximize the quality function called modularity.

Habib Shahet et al. [33], [2018] suggested the objective of this work is to present a Quick Gbest Guided artificial bee colony (ABC) learning algorithm to train the feedforward neural network (QGGABC-FFNN) model for the prediction of the trends in the stock markets. In this respect, in the present manuscript, they propose an algorithm based on ABC to minimize the error in the trend and actual values by using the hybrid technique based on neural network and artificial intelligence. The presented approach has been verified and tested to predict the accurate trend of Saudi Stock Market (SSM) values.

Hyejung Chung et al. [34], [2018] recommended This research investigates the temporal property of stock market data by suggesting a systematic method to determine the time window size and topology for the LSTM network using GA. Especially in the field of finance, they have great opportunities to create useful insights by analyzing that information, because the financial market produces a tremendous amount of real-time data, including transaction records. Accordingly, this study intends to develop a novel stock market prediction model using the available financial data.

Mohamed Amine Nemmich et al. [35], [2018] recommended The Bees Algorithm (BA) is one of the most recent swarm-based meta-heuristic algorithms that mimic the natural foraging behavior of honey bees in order to solve optimization problems and find the optimal solution. Four real-life data sets are applied to validate the proposed algorithm, and results of this study are compared to BA and others state-of-the-art methods. In the BAMS algorithm, a simple memory scheme is introduced to prevent visiting sites which are close to previously visited sites and to avoid visiting sites with the same fitness or worse. In this work, an improved Bees Algorithm with memory scheme (BAMS), which is a modified version of the BA algorithm, is used for data clustering. Clustering analysis, used in various science fields and applications, is an important tool and a descriptive process attempting to identify similar classes of objects based on the values of their attributes.

Dervis Karaboga et al. [36], [2007] recommended ABC algorithm is used for optimizing multivariable functions and the results produced by ABC, Genetic Algorithm (GA), Particle Swarm Algorithm (PSO) and Particle Swarm Inspired Evolutionary Algorithm (PS-EA) have been compared. Artificial Bee Colony (ABC) Algorithm is an optimization algorithm based on the intelligent behavior of honey bee swarm.

James Kennedy et al. [37], [1995] suggested benchmark testing of the paradigm is described, and applications, including nonlinear function optimization and neural network training, are proposed.

6. Conclusion

In review the various bee colony algorithms and literatures show that different algorithm gives different result if compare one to another algorithm then they give better result. There is lots of opportunity to improve the search performance. In research it is still needed to identify the problems where ABC algorithm can do better as compared to other optimization algorithms. In future there is opportunity to improve the search performance using hybrid artificial bee colony algorithm and particle swarm optimization.

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