Artificial Bee colony and its Application: An Overview

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***Abstract*-The Artificial Bee Colony is a swarm based meta-heuristic algorithm for optimizing numerical based problem and provides the solution with accuracy and less effort, cost, time and space. Here the word meta heuristic means to provide a better solution to the given problem especially in the case of incomplete or imperfect information. In ABC algorithm, bees search best food source from many food sources and during searching best source, it consider various parameter like nectar amount (fitness value of food source), time etc. This algorithm was inspired by the foraging behavior of honey bees swarm, to look for the best solution to an optimization problem. The model which uses this algorithm has 3 essential components: Employed bees, Unemployed bees and the food sources. The employed or scout bees basically wander for the rich food sources which can be close to their hive. In this algorithm, a crowd of artificial forager bees that are the agents of the environment starts searches for the rich food sources i.e. the good solution for the given problem. and to apply this algorithm, the examined optimization problem is first transformed to the problem of analyzing the best parameter vectors for the given array vectors to minimizes the objective function. Then the artificial bees randomly and unexpectedly find a population of initial solution vectors which can be then improved by employing some strategies i.e. forwarding towards the better solutions in terms of neighbour search parameter mechanism.**

***Index Terms:*-Artificial Bee colony, Honey Bee, Optimization,Swarm Intelligence**

I. INTRODUCTION

Today solving optimization problem is one of the vital topic of concern. The reason is one optimization method may work efficiently for one variety problems but may not work for other variety. There are basically two types of modern optimization technique [1] exist i.e. evolutionary algorithm (EA) and swarm intelligence based algorithm. Evolutionary algorithm works on survival for the fittest theory. It is a simple method in which next candidate solution is produce by moulding some properties of old solution based on the fitness value but the main difficulties in evolutionary algorithm is distinction between new candidate solutions with the older one. In addition to that "premature convergence" and "slow finishing"is the major drawback in this algorithm.

Swarm intelligence method is the branch of study in which individual member combine themselves to achieve a single goal. All the swarm intelligence are basically based on natural behavior of some kind of species[1] such as group of ants constitute ant colony, group of bees constitute bee colony, group of particle constitute particle swarm[2] etc.

Among all the swarm based algorithm artificial bee colony (ABC) optimization technique is one of the best optimization techniques so far. It is basically a meta heuristic optimization technique which is inspired by livelihood of bees. There are basically three types of bees present in bees colony optimization employed bees, onlooker bees and scout bees.

The bees which are associated with a particular food source is known as employed bees.

This employed bee conveys information through a dance known as **waggle** dance.

The Bees which waits in the hive for choosing food source is known as onlooker bee.

The bees which randomly search for food nearby hive area is known as scout bees.

Here no. of food source equal to no of employed bees equal to no. of onlooker bees.

In ABC food source represents possible solution to be optimized i.e. nectar amount represents quality of the solution represented by that food source. As nectar amount increases quality of finding optimal solution increases [3]

In the ABC algorithm, each cycle of the search consists of three steps: sending the employed bees onto the food sources and then determine their nectar amounts; selecting of the food sources by the onlookers after sharing the information of employed bees and determining the nectar amount of the foods; determining the scout bees and then sending them onto possible food sources.

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I. BEHAVIOUR OF HONEY BEES

The honey bee swarm consists of three important components: food source, employed foragers and unemployed foragers. The model describes two modes of operation: the recruitment to a nectar source and abandonment of a source.

Food source: The value of a food source depends upon its nearness, richness of energy and possibility of extraction [4]. Let us consider the food source of size SN, number of artificial bee is NP. The expression of the initialize food source that randomly produces are

$X_m=l_i+rand(0,1)^*(u_i+l_i)$ where

X_m=vector to the optimization problem (has D variables ; D-dimension of the searching space)

U_i& l_i= upper and lower bound of the solution space of objective function

rand(0,1)= random number within the range [0,1]

Employed foragers: They are related to a particular food source. They are carrying the information of exploiting food source such as its distance and direction from nest, profit-making of the source. They also share its probability information. Let the neighbouring food source be v_{mi} and it's calculated by the equation is

$V_{mi}=X_{mi}+\Phi_{mi}(X_{mi}-X_{ki})$

Where

X_k=randomly selected food source

i=randomly chosen parameter index

Φ_{mi}=a random number within the range [-1,1]

Unemployed foragers: They are always look out for food source. They are of two types: scout and onlookers. The scouts are searching for new food sources. The onlookers are waiting in the nest and they decode the information about food source shared by employed foragers.

By examining the hives the most important part is the dancing area. In this dancing area, the information about quality of food source exchanges among the bees. These types of dance is called **waggle dance**.

The onlookers are informed with the availability of rich source on the dance floor. As more information is provided about more profitable source, the probability of onlookers to select those profitable sources is always high (i.e. probability is proportional to the profitability of the source). The more profitability of the source the longer is the sharing of information through waggle dance.

In order to explain this behaviour let us take the figure given below.

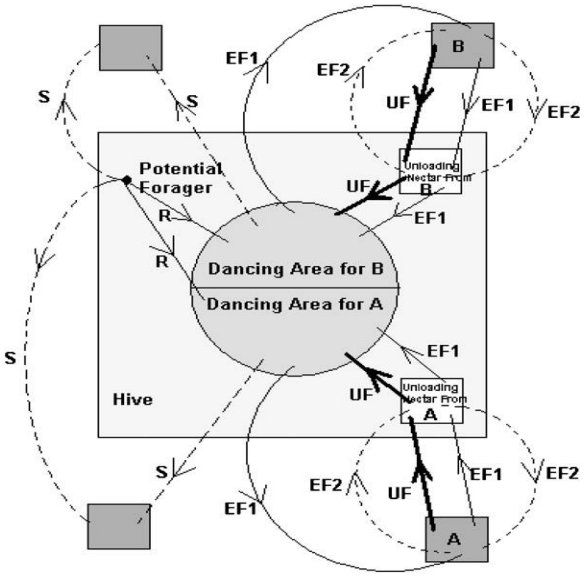

Fig 1:-The behaviour of honey bee foraging of nectar

Let us take two discovered food source i.e A & B. At the starting a forager starting as the unemployed forager having no knowledge about the food source near the nest. It has two possibilities

- It can be scout and start searching around the nest for food which is represent by S on figure
- It can recruit after watching the waggle dance and searching for food which is represent by R in figure.

After locating the food source and memorizing it the bee becomes employed forager and starts exploiting

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it. It takes the nectar and unload it to a food store, then it has three option

- After abandoning the food source it become an uncommitted follower (UF).
- It dance and recruits other before returning to the same food source (EF1).
- It continues to forage at food source without recruiting other bees (EF2).

II. STANDARD BEES ALGORITHM

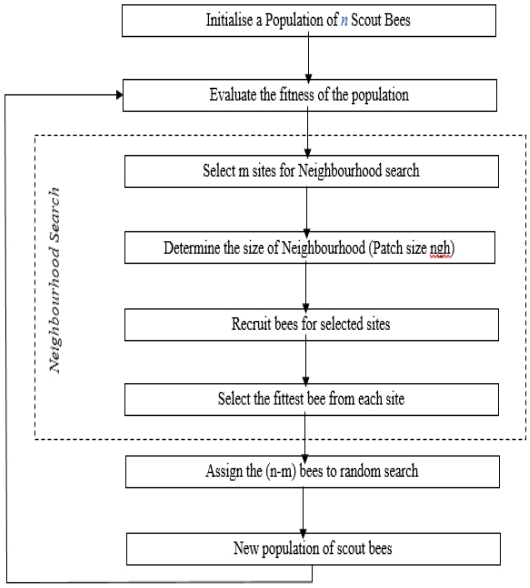

Fig 2:-Flow chart of standard bee algorithm

Working Step of Bees algorithm.

Step-1:-This algorithm starts with 'n' scout bees which are randomly placed in search space.

Step 2:-The fitness of the visited sites by scout bees are evaluated as the first scout bees is taken and trained with the data (for example if we get 300 correct result out of 1000 record, the bee will give the evolution of 30%) and the same process is repeated on all the scout bees and evaluates the fitness, which changes upon the studied problem. The evaluation of n scout bees are stored in an array from higher to lower.

Step 3:- The m-sites will be select randomly (best evaluation to m-scout bees) from n scout bees. Then we select best e-site/s (scout bees) out of m-scout bees.

Step 4:- We select neighbourhood sites of size 'ngh' and it is used to update the m bees because there may be a possibility of having a better solutions than the original one in its neighbourhood area.

Step 5:-After selecting neighbourhood sites of size 'ngh' we recruit bees for those sites and evaluates the fitness.

Step 6:- Select best bees from each sites to form next bee population. This step doesn't exist in nature, it has been only placed in algorithm to reduce the no. of sites to be explored

Step 7:- This step initializes new population (we assign the remaining (n-m) bees to search randomly in search space).

Step 8:- Step 2 to 7 repeat until the stopping criteria are met (for eg. maximum 100)

III. AN EXAMPLE

To understand how bees algorithm works let us examine it by an example.

Here figure (3) represents a random mathematical function which we have to optimized by ABC algorithm.

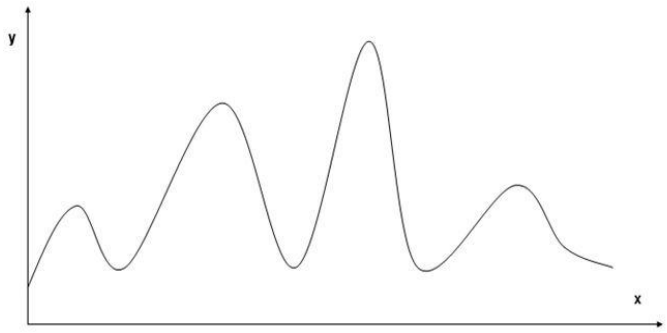

Fig 3:-A mathematical function.

- Here first step let us initialize with 10 population of scout bees to search randomly and find out fitness of all as shown in figure (4)

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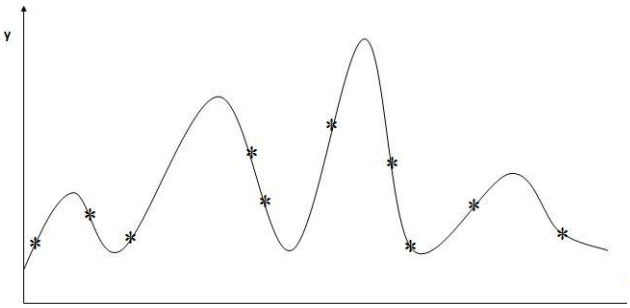

Fig 4:-Initialize with (n=10) scout bees to search randomly.

- The best m-sites is selected from total n bees

(Here m=5, elite bee (rich sites bee) (e)=2,m-e=3(poor sites bee) for other selected bees) as shown in fig(5)

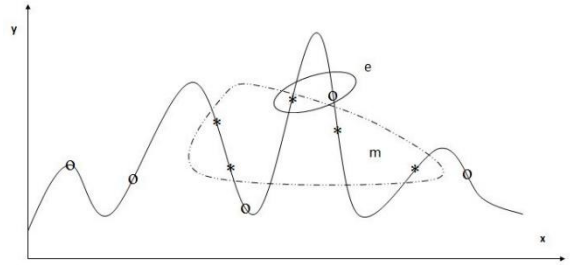

Fig 5:-Select best (m=5 sites for neighbourhood search, e=2(elite bees) and (m-e)=3 other selected bees

- We have to determine the size of neighbourhood as shown in fig(6)

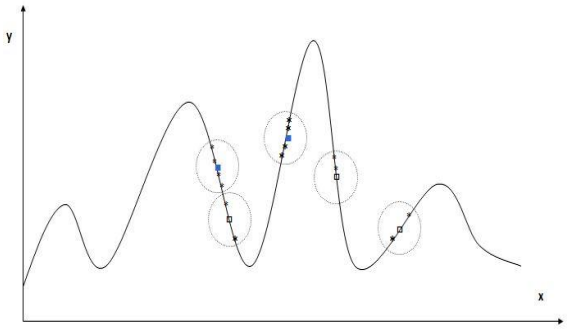

Fig 6:- determine the size of neighbourhood

- Assign more bee to rich site (say 4),less bees to poor sites(2) as shown in fig(7)

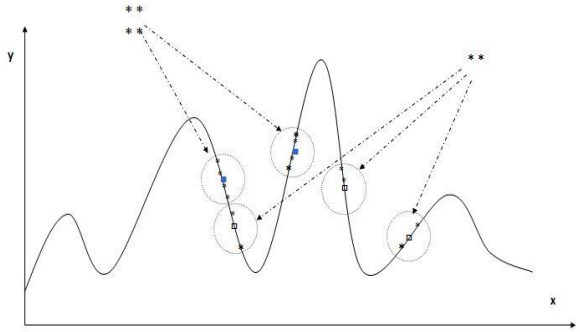

Fig 7:-Recruit bees for selected sites (more bees for e=2 elite sites)

- Select best bees from each best location to from new bees as shown fig (8)

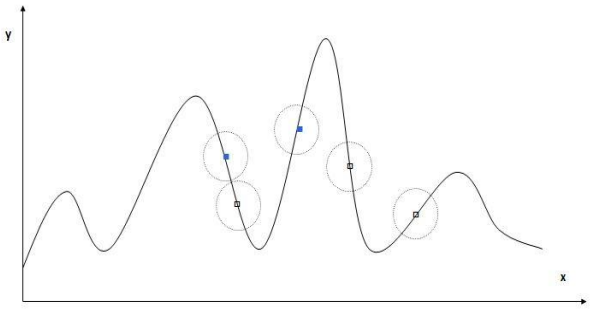

Fig 8:-select the fittest bees ***** from each sites

- Assign remaining (n-m) bees to random search as shown in fig (9)

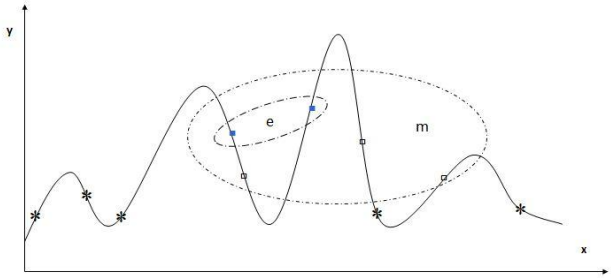

Fig 9:- Assign remaining n-m bees to random search

- The loop counter is reduced until stopping criteria is reached at the end best solution is reached as shown in fig (10)

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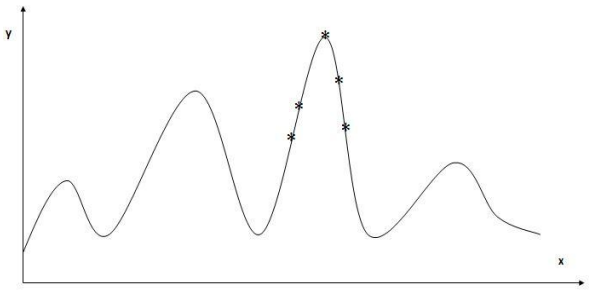

Fig 10:-find the global best point

IV. Application of Artificial Bee Colony Algorithm

Now as far as algorithm is concerned this has fast variety of application in the field of control system engineering, power system engineering, bio-engineering ,manufacturing, data clustering etc.

Here we have presented just an overview of different application

a) Optimal Reactive power dispatch(ORPD):-

Here the problem is to minimize real power loss and deviation of different voltages at different bus.

The power flow can be generalised as below

Minimize f(x, u)

Subject to g(x,u)=0

and h(x,u) ≤ 0

Where f(x, u) is the objective function, g(x.u) and h(x,u) are equality and inequality constraints. Here x,u are state and control variable

The objective function for reactive power dispatch for minimizing active power loss given by

PL=$\sum_{i=0}^{n} plossi = 0$

Where n=no of bus

The steps are as follow

Step-1: Input system data (no of Bus, no of branches etc)

Step-2:Input ABC variable (max iteration, limit valued etc)

Step-3: Input food value randomly (here different generator voltage tap position of different transformer)

Step-4:Run the power flow using above data

Step-5:Is power flow converged

Step-6: If not converged go to step-3 and modify

Step-7:If yes find$\sum ploss$ and store it.

b) Chaotic search ABC

In ABC algorithm the solution founded by using local search strategy is not very accurate [5][6][7]. So to increase the accuracy of the solution and its fine convergence ability we use the chaotic search algorithm [8](also known as improved ABC algorithm). In this method the chaotic sequence is being used to increase the local search behaviour and to avoid being trapped in to local optimum [9].

PID controller tuning based on CABC:-

In industrial process control system PID controller has been widely used for its simple structure, robust performance within wide range of operating condition. But it's difficult to tune its parameters properly due to problems such as: high order, time delay, nonlinearity, and the fact that mathematical model of plant is difficult to determine. In this situation the controller must have function of parameter self-tuning and good tuning effect [10].

Conventional PID parameter tuning method use proportional, integral & derivative three steps and change parameter until satisfactory result obtained. But it has its own limitation. Now a days several heuristic methods has been proposed for tuning of PID parameters. The emergence of intelligent optimization methods provides a new approach to tuning PID parameters [11][12]13][14][15].Chaotic artificial bee colony is one of the best suitable method for PID parameter tuning.

c) Application in data clustering:-

Clustering means partition a given set of data into groups or class. Data clustering is used in various field like data mining, machine learning, pattern recognition etc. It is also applied in a large variety of applications, such as image segmentation, objects and character recognition, document retrieval, etc.[16].There are various methods which is used in data clustering like hierarchical clustering, partition-based clustering, density-based clustering, and artificial intelligence-based clustering.

One popular class of clustering method is the centre based clustering i.e., K-means. K-means algorithm is used in clustering due to its simplicity

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and high speed clustering in large data set but it has two disadvantages: (i) dependency on initial state and (ii) convergence to local optima and global optima solutions of large problems cannot found with a reasonable amount of computation effort. To overcome local optimum problem lots of studies done on data clustering and found that honey bees are the best compare to other solution.

V. CONCLUSION

In this paper, an overview of artificial bee colony algorithm and its application in various fields are presented. In addition to we have covered foraging behaviour of honey bees, how bees choose food source and how it finds best food source among all other food sources. Due to its strong robustness, fast convergence, high flexibility and fewer control parameters, it is used in various fields of applications in real world. Generally ABC is good in exploration but bad in exploitation so to balance these two parameter we can integrate genetic algorithm with ABC to improve its efficiency.

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