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NATURE INSPIRED METAHEURISTIC ALGORITHMS-A COMPARATIVE REVIEW

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ABSTRACT

Many metaheuristic algorithms are used for solving different optimization problems efficiently. From these metaheuristic algorithms, nature-inspired optimization algorithms are widely used to find better solutions and their best results. In this paper, five types of metaheuristic algorithms such as Particle swarm optimization (PSO) algorithm, Bee colony optimization (BCO) algorithm, Bat algorithm (BA), Cuckoo search (CS), Firefly algorithms (FA) were used as the basis for comparison. Particle swarm optimization algorithm is based on the interactions between social insect, swarms. The Bee colony optimization algorithm is influenced by the foraging behavior of honey bees. Cuckoo search uses brooding parasitism of cuckoo species and bat algorithm is inspired by the echolocation of microbats. Firefly algorithm is emphasized by the flashing behavior of swarming firefly.

INTRODUCTION

Optimization is a process to take best values of different parameters of the specific problem under specified conditions, i.e. generally it automatically finds the different parameter values which enable an objective function to generate the maximum or minimum value. An optimization algorithm is a procedure which is executed iteratively by comparing various solutions till an optimum or a satisfactory solution is found. Metaheuristic algorithms are considered to be the most efficient algorithms to solve the optimization problems because of their easy implementation and gives better results. Nature inspired algorithms are widely used to find the best solutions for various optimization problems. In this paper a comparative study of Nature inspired metaheuristic optimization algorithms is presented based on the objective function (Iztok Fister *et al.*, 2013; Yang, 2011). In this paper our aim is to compare five types of nature inspired metaheuristic algorithms such as Particle swarm optimization (PSO) algorithm, bee colony optimization (BCO) algorithm, bat algorithm (BA),cuckoo search(CS),Firefly algorithms(FA). Section1 describes the brief introduction.

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Section 2 explains the various Nature inspired metaheuristic algorithms with their pseudo-code. Comparison of these algorithms is done in Section 3. Section 4 finally concludes the paper.

NATURE INSPIRED ALGORITHMS

Particle swarm optimization (PSO)

The PSO that is proposed by Eberhart and Kennedy in 1995. PSO is a meta-heuristic algorithm inspired by the group behavior of animals like bird flocks or fish schools. In PSO algorithms, the population P={p1,…,pn} of the feasible solutions is often called a swarm. The feasible solutions p1,…,pn are called particles.

For solving practical problems, the number of particles is usually chosen between 10 and 50.At the beginning of this algorithm, the particle positions are randomly initialized, and the velocities are set to 0, or to small random values. Parameters w(inertia weight) usually decreasing from around 0.9 to around 0.4 during the computation and c1,c2 (acceleration coefficients) usually between 0 and 4 (Kennedy and Eberhart, 1995; Wikipedia;http:// en. Wikipedia .org/wiki/ Swarm_intelligence).

The flow chart of Particle Swarm Optimization is depicted in Fig. 1.

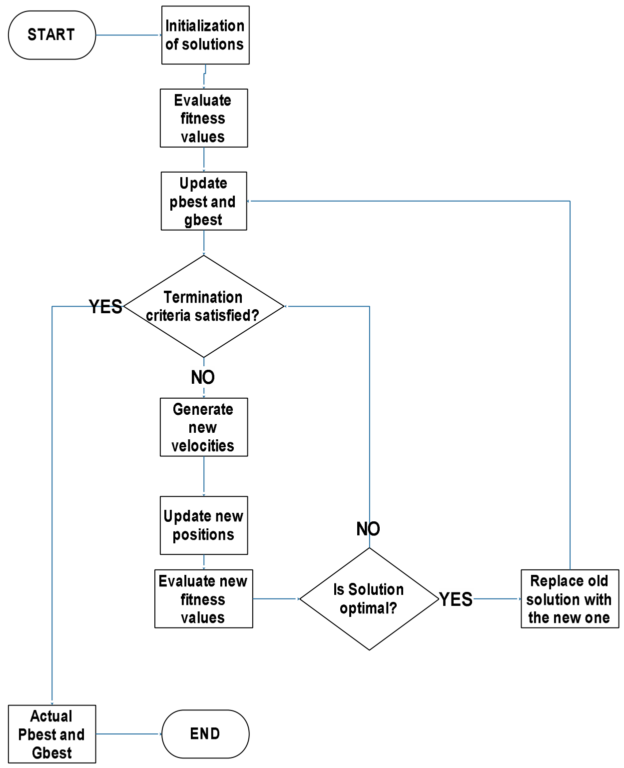


Fig.1. Flow chart of Paticle Swarm Optimization (PSO)

A. Pseudo code of PSO

Initialize the number of generation t=0.

Initialize a swarm population size.

Initialize the swarm position 'x' and velocity 'v'

Evaluate the initial fitness function value 'fx'

Find the local best pbest and global best gbest Initialize different PSO parameters, i.e., c1, c2, w

While (t<Max_Iteration)

Update velocity v1 by using the following equation

v1=w*v+c1* (best-x) *rand () +c2* (gbest-x) *rand ();

Update position

x1=x+v1

Check the boundary conditions

Evaluate the new fitness function

Update current local best pest and the global best best Generation (t) =Generation (t) +1

End While

Select the solution with best fitness function value

ARTIFICAIL BEE COLONY OPTIMIZATION

Artificial Bee Colony (ABC) is a meta-heuristic algorithm introduced by Karaboga in 2005 (http://www.scholarpedia.org/article/Artificial_bee_colony_algorithm; Karaboga, 2005). This algorithm simulates the foraging behavior of honey bees. Bee Colony Optimization (BCO) is an optimization tool which provides a population based search procedure, where the bees locate the food source positions (http://www.scholarpedia.org/article/ Artificial_ bee_ colony_algorithm; http://en.wikipedia.org/wiki/Bee). The colony of bees in ABC algorithm comprises of three groups of bees: employed bees, onlookers and scouts bees (http://www.scholarpedia.org/article/Artificial_bee_colony_algorithm). Employed bees forage in search of their food source and return to hive .Onlooker bees decide their food source depending upon the dances of employed bees. A nectar source is selected through a nest mate whose food source has already discovered. After collecting the nectar the bees return to their hive to a food store bee. After relinquishing the food, the bee is having one of the alternatives with a certain probability (a) abandon the food source and act as an uncommitted follower, (b) Without enlisting the nest mates, continue to forage at the food source or (c) enlist the nest mates by dancing before the return to the food source. It is also noted that not all bees start foraging simultaneously (http://en.wikipedia.org/wiki/Bee; Karaboga, 2005).

The flow chart of Artificial Bee Colony is depicted in Fig. 1.

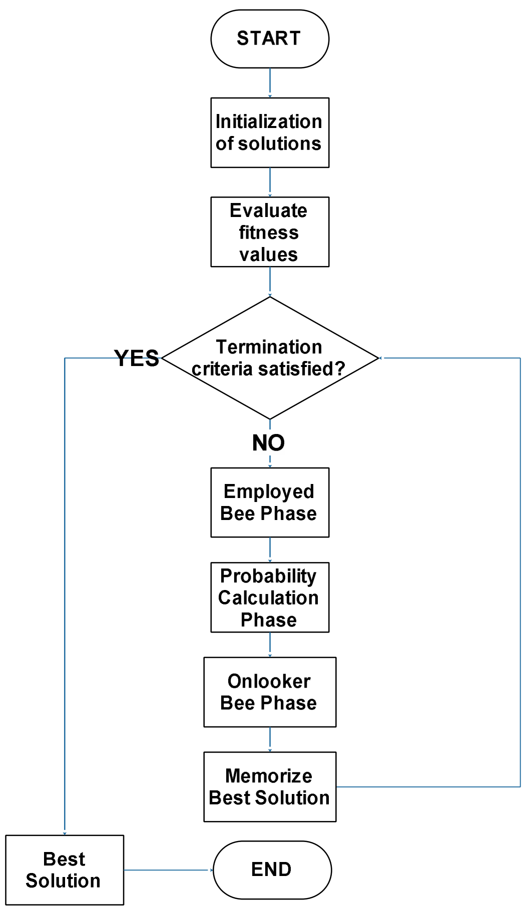


Fig.1. Flow chart of Bee Colony Optimization

B. Pseudo code of BCO

Initialize the number of generation t=0.

Initialize population size.

Evaluate its fitness function value 'fx'.

Find the initial best solution

While generation (t) <500 do

//Employed Bee Phase
Produce new candidate solution
Check the boundary conditions
Evaluate its fitness value
If (fitness (n) >fitness (old))
Then replace the old solution
//Probability Calculation Phase

Calculate the probability of occurrence of each solution P

//Onlooker Bee Phase
If P>Rand ()
Produce new candidate solution
Check the boundary conditions
Evaluate its fitness value
If (fines's (n) >fitness (old))
Then replace the old solution
Memorize the best solution
Generation (k) =Generation (k) +1
End While
Select the best solution having the best fitness value

FIREFLY ALGORITHM

The Firefly algorithm was introduced by Dr. X.S. Yang at Cambridge University in 2008.This algorithm was inspired by the mating or flashing behavior of fireflies. The behaviors of fireflies or lightning bugs belong to a family of insects which are capable to produce natural light to attract a mate or prey. The intensity (I) of the flashes, decrease as the distance (r) increase and thus most fireflies can communicate only up to several hundred meters. In the implementation of the algorithm, the flashing light which is associated with the objective function to be optimized (Sankalp Arora and Satvir Singh, 2013).

In firefly algorithm, there are three idealized rules:

- A firefly will be attracted by other fireflies without considering their gender.
- Attractiveness of fireflies is directly proportional to the brightness and the two factors like attractiveness and brightness reduces as the distance among the fireflies' increases.
- A less bright firefly will move towards the brighter firefly. All the fireflies randomly move towards the brightness.
- The objective function determines the brightness of a firefly (Yang, 2009) (Sankalp Arora and Satvir Singh, 2013).

The flow chart of Firefly Algorithm is depicted in Fig. 1.

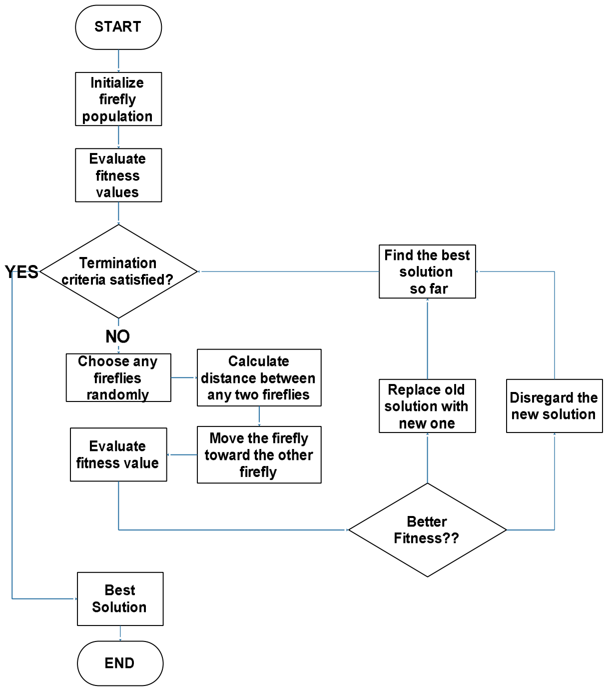


Fig.1. Flow chart of Firefly Algorithm

The pseudo code of the Firefly algorithm can be

C. Pseudo code of FIREFLY

Initialize the number of generation t=0.

Initialize fire flies population size.

Generate initial solutions
Evaluate the initial Light Intensities value 'I'
Find the initial best solution
Define light absorption coefficient γ
Initialize different Firefly parameters i.e. β_0, α.
While generation (t) <500 do
For i=1 to n fireflies
For j=1 to n fireflies
If Intensity (j) >Intensity (I)
Evaluate distance r.

Update new solution with the help of following equation
$xnew=x(i)+\beta_0*e^{-\gamma r}*(x(j)-x(i)+min\_val*\alpha*(rand-0.5)$

Check the boundary conditions
Evaluate the new fitness function
End if
End for
End for
Update current best solution
Generation (t)=Generation(t)+1
End While

Select the solution with best fitness function value

CUCKOO SEARCH (CS) ALGORITHM

The Cuckoo Search (CS) a metaheuristic algorithm which is population based, where each pattern corresponds to a nest and each individual attribute of the pattern corresponds to the egg of the bird (Sankalp Arora and Satvir Singh, 2013). This algorithm is based on the brooding characteristics of the cuckoo bird through their species where they lay their eggs in the nest of host birds. Host birds either throw their eggs away or destroy their nests if they find that eggs do not belong to them. Some cuckoo species like Tapera have evolved in such a way that female parasitic cuckoos are often specialized in the mimicry in colors and pattern of the eggs of a few chosen host species (Yang and Deb, 2009).
CS is based on three idealized rules:

- Each cuckoo lays one egg at a time, and dumps its egg in a randomly chosen nest;
- The best nests with high quality of eggs will carry over to the next generation;
- The number of available host nest is fixed and the egg laid by a cuckoo is discovered by the host bird with a probability P_a€ (0,1). In this case the host bird can either throw the egg away or abandon the nest so as to build a completely new nest in a new location.

The host can discover an alien egg with a probability. The egg in a nest represents a solution while the cuckoo's egg represents a new solution. The main aim is to achieve better solutions by employing a new better egg, which is from cuckoo to replace not so good solutions in the nest (Nitesh Sureja, 2012; Sankalp Arora and Satvir Singh, 2013).

The flow chart of Cuckoo Search is depicted in Fig. 1.

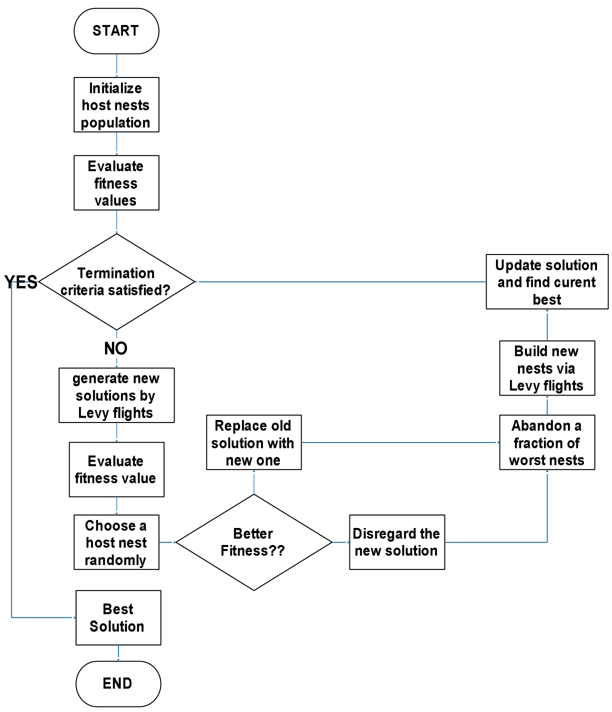


Fig.1. Flow chart of Cuckoo Search

D. Pseudo code of CUCKOO search

Initialize the number of generation t=0.
Initialize population size.
Evaluate its fitness function value 'fx'
  Find the initial best solution
While generation(t)<500 do
  for i=1 to no_of_cuckoo
    Get a cuckoo randomly by Levy flights
    Calculate different parameters
    Produce new solution
    Check the boundary conditions
    Evaluate its fitness value
    If (fines's (n)>fitness(old))
      Then replace the old solution
    Calculate probability of occurrence of each solution
    Abandon a fraction of worst nest having probability < pa
    Build new nest at new location via Levy Flights
    Check the boundary conditions
    Rank the solution and find out the current best
  End for
  Generation (k) =Generation (k) +1
End While

Select the best solution having the best fitness value

BAT ALGORITHM(BA)

Bat-inspired algorithm is a metaheuristic search optimization algorithm. It was introduced by X.S Yang in 2010. This algorithm is based on the echolocation behavior of bats with loudness and varying pulse emission (Sankalp Arora and Satvir Singh, 2013). The characteristics of bat's echolocation can be summarized as:

Bat use echolocation to sense the distance and have a magical mechanism to differentiate between prey and barrier even in the darkness. To search prey, they fly randomly with velocity vi, at position xi with fixed frequency fmin, loudness A0 and wavelength λ. Loudness varies between A0 (maximum value) to Amin (minimum value). Frequency ranges between fmin and fmax and wavelength ranges between λmin and λmax.

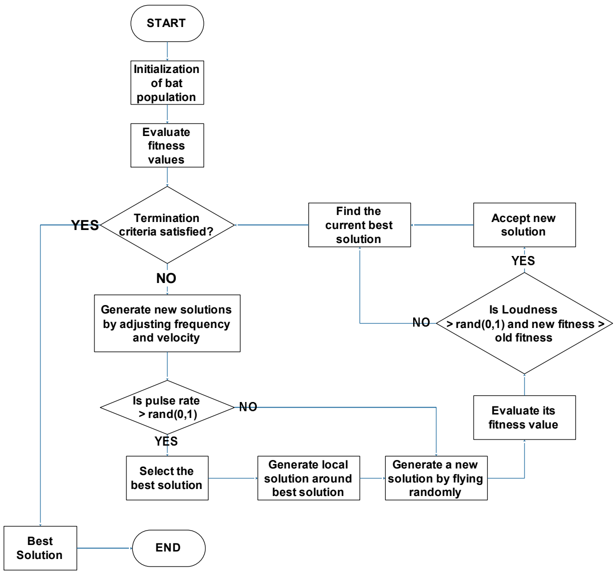
When bats start to search for food or prey, they will produce pulses with maximum loudness. As they approach the prey, the loudness decreases. As soon as the bat finds the prey, the loudness becomes the minimum possible value (usually zero), in order to avoid the loss of prey. Similarly, as the bat goes closer to the prey, the pulse emission rate gets increased. Once they find the prey, the pulse emission rate becomes the maximum possible value (Yang, 2010). Each bat is assigned a starting position which is the initial solution.

The pulse rate and the loudness are defined randomly. Every bat will move from local solutions to global best solutions afterevery iteration. The values of pulse emission and loudness are updated if a bat finds a better solution after moving. This process is continued till the termination criteria is satisfied. The solution which achieved is the final best solution (Homayun Afrabandpey *et al*., 2014; Nitesh Sureja, 2012).

Table 1. A comarative review of different natural meta heuristic algorithms

Algorithm	A year of development	Developed by	Based on	Objective function defined by	Results
PSO	1995	Ebehart & Kennedy	Behavior of animals like bird flocks or fish schools	Position, velocity, weight & acceleration coefficients	Good
BCO	2005	Karaboga	Foraging behavior of honey bees	Fixed number of regions within a search space at one time	Better
Firefly	2008	X.S. Yang	Flashing behavior of firefly	Light Intensity (Brightness) & attractiveness	Better
Cuckoo search	2009	X.S. Yang & suash Deb	Brood parasitism of cuckoo	Colour of eggs	Not so Good
Bat algorithm	2010	X.S. Yang	Echo location behavior of microbat	Velocity & pulse rate emission	Not so Good

The flow chart of Bat Algorithm is depicted in Fig. 1.



E. Pseudocode of BAT Algorithm

Initialize the number of generation t=0.
Initialize population size.
Evaluate its fitness function value 'fx'
Find the initial best solution
While generation (t) <500 do
  Generate new solution by adjusting frequency and updating
    Velocities and its position
  If Rand> pulse rate r
    Generate a local solution around the best solution
    Check the boundary conditions
    Evaluate its fitness value
    If (fines's (n) >fitness (old) and Rand <A)
      Then replace the old solution
  End if
  Rank the solution and find out the current best
  Generation (k) =Generation (k) +1
End While
Select the best solution having the best fitness value

COMPARATIVE ANALYSIS OF VARIOUS NATURE INSPIRED ALGORITHMS

We have presented a comparative review of five metaheuristic natures inspired algorithms by considering the case study,that is withdrawal operation of an ATM.

The following table is represented through this case study, year of development and factors defined by the objective functions with results.

Conclusion

Some of the algorithms, like PSO, BCO, Firefly, cuckoo and Bat have been analyzed based on some parameters. We reviewed various research papers from various authors and have drawn a conclusion that these algorithms have the ability to solve various optimization problems. From the comparison of PSO, BCO, Firefly, cuckoo and Bat optimization algorithm, it is clear that BCO and Firefly algorithms are the most efficient optimization algorithms as well as the favorable optimization tool. In future we analyze more such algorithms using different parameters for automated test case generations.

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