New Inspirations in Nature: A Survey

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ABSTRACT
Over the past few decades, the studies on algorithms inspired by nature have shown that these methods can be efficiently used to eliminate most of the difficulties of classical methods. Nature inspired algorithms are widely used to solve optimization problems with complex nature. Various research works are carried out and algorithms are presented based on that during last few decades. Recently, some new algorithms inspired from nature are proposed to further improve the solutions obtained by the algorithms presented before. In this paper, a survey of five recently introduced Nature inspired algorithms is carried out. They include Firefly algorithm (FA), Cuckoo Search (CS), and Bat Inspired Algorithm (BA). Each of these algorithms are introduced and applied on various numerical optimization functions by various authors. We have tried to review and study the papers published by the authors and present a conclusion of this survey based on the results obtained.

Keywords
Firefly Algorithm, Cuckoo Search, Bat Algorithm

1. INTRODUCTION
Nature inspired algorithms are probabilistic search methods which simulates the natural evolution or the behavior of the natural entities. These algorithms are used very widely to find an optimal solution for various optimization problems as they produce best solutions. Genetic Algorithm (GA) [1], Ant Colony Optimization [2], Simulated Annealing (SA) [3], Differential Evolution (DE) [4] and Particle Swarm Optimization (PSO) [5] and Bee colony Optimization [6] are some example of them. All of them suffer from some problems though they work very well. A new category of classical evolutionary optimization algorithms has emerged to cope with the problems faced by the above algorithms. Firefly algorithm (FA) [7][8][9][10], Cuckoo Search (CS) [10][11][12][13], and Bat Algorithm (BA) [10][14][15][16][17][18] are the some recently introduced powerful optimization algorithms to list them. They are successfully applied to many problems. In this paper a comparative survey of performances of these recently introduced algorithms is presented. Performance comparison is carried out based on the results obtained by the authors, while aplying them to certain benchmark functions.

This paper is organized as follows. A brief introduction is given in section 1. A brief discussion of FA is given in section 2. Section 3 discusses the Cuckoo Search. A discussion on Bat algorithm is presented in section 4. The details and a discussion of results obtained by various authors are given in section 5. Finally paper ends with the conclusion, acknowledgment and references with the sections 6, 7 and 8 respectively.

2. FIREFLY ALGORITHM
X. S. Yang [7][8][9][10] introduced the Firefly Algorithm (FA) in 2008. It is a nature-inspired algorithm. It is inspired by the fireflys' light emission, light absorption and the mutual attraction behaviors. Firefly algorithm was developed to solve the continuous optimization problems initially. Later on it is modified for solving discrete problems like Quadratic Assignment Problem (QAP), Traveling Salesman Problem and various other problems. The Firefly Algorithm is one of the newest meta-heuristics .

As The firefly algorithm (FA) is an inspiration from the flashing behavior of fireflies. Firefly uses its flash as a communication medium to attract other fireflies. These flashing characteristics of fireflies inspire to develop algorithms based on them. Following three idealized rules are formed to achieve simplicity for describing FA.

1. All fireflies will be attracted by each other without considering their sex.
2. The attractiveness of fireflies is directly proportional to the brightness of them, and both of them reduce with the increase in the distances between them. Normally a less bright one will move towards the brighter one. They will move randomly in case of same brightness.
3. In no case a less bright one can attract the brighter one then that and it moves randomly.

Generally the brightness of a firefly is related to the landscape of the objective function. In a case of maximization problem, it is considered to be proportional to the objective function value. The way used by genetic algorithms to form the objective functions can simply be followed for defining the other forms of brightness. The pseudo code of (FA) is as shown in figure 01 based on the rules as well as the objective function information.

The process of firefly algorithm starts with the initialization of the population of fireflies. Each firefly in a population represents a candidate solution. The size of the population determines the number of solutions or the size of the search space. In the next step, each firefly is evaluated based on their fitness (Light Intensity). Distance between any fireflies can be defined as a Cartesian distance. The distance function developed is used to find the distance between two fireflies. Attractiveness function is defined by using light intensity, distance and an absorption coefficient. Movement of firefly is defined by a movement function. It is defined by using current position, attractiveness and a random walk.

2.1 Pseudo-code of FA
Pseudo-code of firefly algorithm (FA) is given below.

Begin
1) define Objective function;
2) generate an initial population of fireflies;
3) formulate light intensity associated with objective function;
4) define absorption coefficient
5) while (t<MaxGeneration)
{
for i=1:n (all n fireflies)
for j=1:n (n fireflies)
if ($I_j > I_i$),

```
                move firefly i towards j;
        end if
         vary attractiveness with distance ;
         evaluate new solutions and update light intensity;
      end for j
   end for i
   rank fireflies and find the current best;
    }
  6) post-processing the results and visualization;

End
```

Fig. 01 Pseudo-code of FA [7][8][9][10]

3. CUCKOO SEARCH

The Cuckoo Search (CS)[10][11][12][13] was inspired by the breeding process of some cuckoo species where they lay their eggs in the nests of host birds. Some female cuckoos can imitate the colors and patterns of the eggs of a few species which they select as host species. This ability reduces the probability of the eggs being discarded by the host species and increases re-productivity. Some times there can be a direct conflict of host birds with interfering cuckoos. In such a situation, host birds either throw eggs away or they may destroy their nests and build new ones at other place. Cuckoos normally choose a nest where the host bird just laid its own eggs. In general, the cuckoo eggs hatch slightly earlier than their host eggs. Once the first cuckoo chick is hatched, cuckoos evict the eggs of the host by pushing them out of the nest. This act increases the share of food for cuckoo chicks from the host bird.

The egg in a nest represents a solution, while a cuckoo egg represents a new solution. The aim is to achieve better solutions by employing a new better egg which is from cuckoo to replace not-so-good solutions in the nests. In the simplest form, each nest has one egg. The CS is based on three idealized rules:

1. Each cuckoo lays one egg at a time, and dumps it in a randomly chosen nest;
2. The best nests with high quality of eggs (solutions) will carry over to the next generations;
3. The number of available host nests is fixed, and a host can discover an alien egg with a probability.

In this case, the host bird can either throw the egg away or abandon the nest to build a completely new nest in a new location. For simplicity, the last assumption can be approximated by a fraction of the total nests being replaced by new nests, having new random solutions. For a maximization problem, the quality or fitness of a solution can simply be proportional to the objective function. Other forms of fitness can be defined in a similar way to the fitness function in genetic algorithms.

3.1 Pseudo-code of CS

Pseudo-code of Cuckoo Search (CS) is given below.

```
Begin
define objective function.
generate initial population of host nests.
while (criteria not met)
   {
    get a cuckoo randomly;
    evaluate the fitness of it;
    choose a nest from the population randomly;
     if(fitness of selected nest is high)
      end
       Abandon a fraction of worse nests and build new
            ones at new locations;
       keep the best nests (solutions);
      rank the nests and find the current best;
  }
post process results and visualization;

End
```

Fig. 02 Pseudo-code of CS [10][11][12][13]

4.1 Pseudo-code of BA

The pseudo code of Bat Algorithm (BA) is shown in following figure.

```
1. define objective function
2. initialize the population of the bats
3. define and initialize parameters
4. while(Termination criterion not met)
```

4. BAT ALGORITHM

Bat Algorithm (BA)[10][14][15][16][17][18] is a recently introduced nature inspired algorithm. It is introduced by Yang and inspired by behaviors of Bats. The mammals known as Bats have wings and a very good feature of generating echolocation. Yang has used these characteristics of bat for the development of his BA. This algorithm is based on three important rules. They are given below.

1. For sensing distance, bat uses its' echolocation capacity. It also uses echolocation to differentiate between food and prey and background barriers even in the darkness.
2. Bats used to fly randomly with some characteristics like a velocity, fixed frequency and loudness to search for a prey.
3. It also features the variations in the loudness from a large loudness to minimum loudness.

Normally, Bats fly randomly with a velocity, a position and a frequency which is fixed. They also use a varying wavelength and loudness to find the prey. Depending on the proximity of the target, they can automatically adjust frequency of pulses emitted and pulse rate. Here, loudness varies from a large value to a smaller value. For simplicity, the frequency, the new solutions, velocities at a specific time step and a parameter used here is represented by a vector which is random.

Bat Algorithm starts with initializing a population of bats, each of which is assigned a starting position (initial solution), rate of pulse, loudness and a find frequency. Here rate of pulse and loudness are defined randomly. Every bat will move from initial solutions toward global best solution with each iteration. Pulse emission and loudness are updated if any bat finds a better solution after moving. During flying iteration, the best so far solution is updated. This process is repeated continuously till the termination criteria are satisfied. The best so far solution achieved is considered as final best solution.

```
{
 generate the new solutions randomly
 if (Pulse rate (rand)  > current)
   select a solution among the best solution
  generate the local solution around the selected best
  ones.
 end if
generate a new solution by flying randomly
```

if (loudness & pulse frequency (rand) < current)
accept the new solutions
increase pulse rate and reduce loudness
end if
rank the bats and find the current best

}

5. *Results and visualization*

Fig. 03 Pseudo-code of BA [10][14][15][16][17][18]

5. COMPARISION OF RESULTS

In this section, the results obtained for different standard test functions by various authors are collected, displayed and discussed on various parameters. The results are in the form of success rate which is average number of function evaluations required to reach to global optima. Authors have also derived mean values of the function evaluations with a standard deviation in their research work. We have only taken the success rate in percentage to show them in table. Following Table displays the results for Firefly algorithm, Cuckoo search and bat algorithm. This table also consists the results obtained with the Genetic algorithm (GA) and Particle swarm optimization (PSO) for the same. Authors have applied their algorithms on ten various functions. These includes: Michalewicz's, Rosenbrock's, DeJong's, Schwefel's, Ackley's, Rastrigin's, Easom's, Griewank's, Shubert's, Yang's and Multiple peaks function. By observing the table, it is clearly found that the algorithms like FA, CS, and BA produce the best results then the algorithms like GA and PSO.

They almost produces 100% success rate for all the functions used by the authors for their research work. Even the results obtained by the other authors indicates the newer algorithms best. We can simply derive a very high potentiality of these algorithms from the survey.

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Table 1. Results collected for FA, CS, BA, GA and PSO [7][8][11][14]

Functions/Algorithms	GA (%)	PSO (%)	FA (%)	CS(%)	BA(%)
Michalewicz's	95	98	99	100	100
Rosenbrock's	90	98	99	100	100
DeJong's	100	100	100	100	100
Schwefel's	95	97	100	100	100
Ackley's	90	92	100	100	100
Rastrigin's	77	90	100	100	100
Easom's	92	90	100	100	100
Griewank's	90	92	100	100	100
Shubert's	89	92	100	100	100
Yang's	83	90	100	100	100

6. CONCLUSION

We have surveyed some recently introduced nature inspired algorithms like: Firefly algorithm, Cuckoo search and Bat algorithm. We have reviewed the research papers from various authors, who have used them to solve optimization problems. We have considered the results produced by these algorithms for standard test function to conclude with a statement that they have tremendous ability to solve various continuous as well as discrete optimization problems.

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8. REFERENCES

[1] T Holland, J.H. "Adaptation in Natural and Artificial Systems". MIT Press, 1992

[2] M. Dorigo, T. Stutzle, "Ant Colony optimization", A Bradford book, MIT Press Cambridge, Massachucetts london, England (2004) .

[3] David Bookstaber, "Simulated Annealing for Traveling Salesman Problem", Spring, 1997

[4] P. Storn, R. and Price, K. (1997), 'Differential Evolution - A Simple and Efficient Heuristic for Global Optimization over Continuous Spaces', Journal of Global Optimization,11, pp. 341–359.

[5] Kennedy, J.; Eberhart, R. (1995). "Particle Swarm Optimization". Proceedings of IEEE International Conference on Neural Networks. IV. pp. 1942–1948

[6] D. Karaboga, B. Basturk, "A powerful and efficient algorithm for numerical function optimization: artificial bee colony (ABC) algorithm", *Journal of Global Optimization* 39 (2007) 459–471

[7] X.S Yang, "Fire fly algorithm for multimodal optimization", in proceedings of the stochastic Algorithms. *Foundations and Applications (SAGA 109) vol.5792 of Lecture notes in Computer Sciences* Springer,Oct.2009

[8] X. S. Yang, (2010). "Firefly Algorithm Stochastic Test Functions and Design Optimization". Int. *J. Bio-Inspired Computation*, vol.2, No. 2, pp.78-84, 2010.

[9] A. Abdullah, S. Deris, M. Mohamad, and S. Hashim, "A New Hybrid Firefly Algorithm for Complex and Nonlinear Problem", Distributed Computing and

Artificial Intelligence, AISC 151, pp. 673–680, Springer-Verlag Berlin Heidelberg 2012

[10] Yang, X.-S.: "Nature-Inspired Metaheuristic Algorithms ". Luniver Press, (2008)

[11] X.-S. Yang, S. Deb, "Cuckoo search via L´evy flights", in: Proc. Of World Congress on Nature & Biologically Inspired Computing (NaBIC2009), December2009, India. IEEE Publications, USA, pp. 210-214(2009).

[12] E. Valian, S. Mohanna and S. Tavakoli, "Improved Cuckoo Search Algorithm for Global Optimization", International Journal of Communications and Information Technology, IJCIT-2011-Vol.1-No.1 Dec. 2011

[13] Yang, X.-S., and Deb, S. (2010), "Engineering Optimisation by Cuckoo Search", *Int. J. Mathematical Modelling and Numerical Optimisation*, Vol. 1, No. 4, 330–343 (2010).

[14] X.-S. Yang, "A New Metaheuristic Bat-Inspired Algorithm", *Studies in Computational Intelligence*, Springer Berlin, 284, Springer, 65-74 (2010).

[15] P. Musikapun, P. Pongcharoen, " Solving Multi-Stage Multi-Machine Multi-product Scheduling Problem Using Bat Algorithm", 2nd international Conference on Management and Artificial Intelligence, IPEDR Vol.35, 2012

[16] P. W. Tsai, et.al. "Bat Algorithm Inspired Algorithm for Solving Numerical Optimization Problems". *Applied Mechanics and Materials*. 2011, 148-149: 134-137.

[17] X. S. Yang. "Bat algorithm for multi-objective optimization. International Journal of Bio-Inspired Computation. 2011, 3(5): 267-274.

[18] T.C. Bora, L.S. Coelho, L. Lebensztajn, "Bat-Inspired Optimization Approach for the Brushless DC Wheel Motor Problem", IEEE Transactions. 2012, 48(2): 947-950.