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A Comparative Study of Various Metaheuristic Algorithms

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Abstract-Nature inspired algorithms are used over the passed decade that provide efficient methods to resolve optimization problem that where not possible with the conventional methods. The main advantage with these algorithms is that they perform iterative searches efficiently in this context we present comparative analysis of four metaheuristic algorithms namely –Firefly , Bat, Cuckoo search and Krill herd is presented in this paper. The analyses is presented based on its Area of application its characteristics Year of development etc.

Keywords- Firefly, Bat, Cuckoo search, Krill herd, Optimization

I. INTRODUCTION

Natures inspired algorithms are widely used to find best solutions to various optimization problems. Some of the examples of them are genetic algorithm[1], and ACO[2], simulated annealing[3], differential evolution[4], PSO[5] and BCO[6]. All these algorithms though work well but they suffer from some issues. Taking this into account a new category of evolutionary optimization algorithm has emerged. Firefly algorithm[7], Cuckoo search[8], Bat algorithm[9] and krill herd algorithm[10]. In this paper a comparative analysis of these recently introduced algorithms is presented in terms of area of application and its features.

The paper is organized as follows:

Section1 describes brief introduction. Section2 discusses firefly algorithm and its pseudo code. Section 3 and 4 describes cuckoo search and bat algorithm respectively. Section 5 discuss krill herd algorithm in detail. Section 6 gives a comparative study of different algorithms and techniques in tabular form. Finally the paper ends with conclusion and references in section 7 and 8 respectively.

II. FIREFLY ALGORITHM

Firefly algorithm[7][11][12][13] was introduced by X.S. Yang in 2008. Its inspiration is based on light emission, light absorption and mutual attractive behavior among fireflies. Initially, it was developed to solve optimization problems but later on it was used for solving discrete problems like travelling salesmen problem etc. Further it was also used in the fields of digital image processing and compression, clustering.

The algorithm derives its inspiration from flashing behavior of fireflies. The three idealized rules in describing FA algorithm.

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.

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.

A. 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 (Ij> Ii),
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][11][12][13]

III. CUCKOO SEARCH ALGORITHM

The CS [8] algorithm draws its inspiration from breeding process of cuckoo species where they lay their eggs in the nest of host birds. It is a population based algorithm in which some female cuckoos imitate colors and patterns of eggs of a few species which they select a few species. Host birds either throw their eggs away or destroy their nests if they find that eggs do not belong to them.

CS is based on three idealized rules:

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

The egg in a nest represents a solution while the cuckoo 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.

B. 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 [8][14]

IV. BAT ALGORITHM

It was introduced by X.S Yang in 2010. This algorithm is based on echo location behavior of micro bats. It is based on three important rules.

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.

Bats find the prey using varying wavelength and loudness while their frequency, position and velocity remains fixed. They can adjust their frequencies according to pulse emitted and pulse rate.

The algorithm starts with initialization of population of bats. Each bat is assigned a starting position which is a initial solution. The pulse rate and the loudness are defined randomly. Every bat will move from local solutions to global best solutions after every 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 so achieved is the final best solution.

C. 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)

{
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 (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[9][14][15]

V KRILL HERD ALGORITHM

The algorithm was proposed by Gandomi and Alavi in 2012[10].It is based on the herding behavior of the krill individuals. The main objective of krill movement is distance of each krill from the food source. The herding of the krill is multiobjective process including two main goals: (1) increasing krill density and (2) reaching food.

The time dependent position of individual krill in 2D surface is governed by the following three main actions:

1. Movement induced by other krill individuals.
2. Foraging activity
3. Random diffusion

In this process an individual krill move towards the best solution when it searches for the high density and food i.e. the closer the distance to the high density and food, the less the objective function.

D. Pseudo Code for krill herd

1. Begin
2. Step1: Initialization. Set the initial generation counter = 1.
3. Initialize the population P on NP krill individuals randomly and each krill corresponds to a potential solution to the given problem;

4. Set the foraging speed V_f, the maximum diffusion speed D^{max}, and the maximum induced speed N^{max};
5. KEEP: how many of the best krill to keep from one generation to the next.
6. Step2: Fitness evaluation each krill individual according to its position.
7. Step3: While the termination criteria is not satisfied or t < MaxGeneration do
8. Sort the population/ krill from best to worst
9. Store the KEEP best krill as KEEPKRILL
10. For i=1;NP(all krill) do perform the following motion calculations.
11. Motion induced by the presence by the other individuals
12. Foraging motion
13. Physical diffusion
14. Update the krill individual position in the search space by (6).
15. Evaluate each krill individual according to its new position X_{i+1}.
16. End for i
17. Replace the KEEP worst krill with KEEP best krill stored in KEEPKRILL.
18. Sort the population/krill from the best to worst and find the current best
19. T= t+1;
20. Step4: End while
21. Step5: Post processing the results and visualization.
22. End

VI. COMPARATIVE ANALYSIS OF VARIOUS NATURE INSPIRED ALGORITHMS

We have presented below a comparative analysis all the metaheuristic algorithms in the form of a table based on its year of development, area of application, objective functions and its features.

Algorithm	Year of Development	Developed by	Based on	Objective function defined by	Features	Area of Application
Firefly	2008	X.S Yang	Flashing behavior of fire fly	Brightness(light intensity) and attractiveness	High convergences rate, robust rate. Finds good optimum solutions in less number of iterations.	Quadratic assignment problem, Travelling salesmen problem, digital image processing
Cuckoo Search	2009	X.S Yang, Suash Deb	Obligate brood parasitism of cuckoo	Colour of eggs	Implementation is simpler	Path generation, test data generation, nano electronic technology
Bat algorithm	2010	X.S Yang	Echo location behavior of micro bat	Pulse rate emission and velocity	Accurate and efficient	Engineering design and classification
Krill Herd	2012	Gandomi and Alavi	Herding behavior of krill	Distance from the food source	Efficient, out performs many of its variant	Crowd simulation, controlling nanobots for cancer detection

VII. CONCLUSION

Some of the algorithms like Firefly, Cuckoo, Bat and Krill Herd have been analysed based on some parameters. We have reviewed research papers from various authors and have arrived at a conclusion that these algorithms have tremendous ability to solve various discrete optimization problems. In future we wish to analyze more such algorithms using different parameters.

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