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Evaluation of Cuckoo Search and its Variants with Levy flight on Benchmark Functions

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Abstract: ***This paper introduced Adaptive and Improved Cuckoo search algorithm based on Cuckoo search algorithm. Cuckoo search algorithm uses parameter with fixed value at the time of initialization, which results in reduction of searching and performance. Improved cuckoo search used the dynamic allocation of the parameters and calculation, it is possible to improve the performance of the algorithms. To improve the parameters on dynamic scale, improved cuckoo search has been used. The motive of Adaptive cuckoo search is to decide the step size adaptively from its fitness value without using levy distribution. Cuckoo search, Improved Cuckoo search and Adaptive Cuckoo search Algorithm have been evaluated with & without levy flight on different benchmark functions, improved cuckoo search provide significantly better results in comparison of cuckoo search, also Adaptive cuckoo search provide better results in less time in comparison of standard cuckoo search.***
Keywords: Cuckoo Search algorithm, Improved Cuckoo search algorithm, Levy flight, Benchmark functions.

I. INTRODUCTION

Nature inspired strategies are very well known and helpful to provide optimized results for NP-Hard problems such as travelling salesman problem,0-1 knapsack problems and many more. There are many nature inspired algorithms available which are used to get effective and efficient search results on the basis of different random walk such as levy flight, Cauchy distribution, Gauss distribution and Benchmark functions such as Rosenbrock function, Ackley's function, Griewank function, Rastrigrin function, Sphere function. Cuckoo search algorithm which is a meta-heuristic optimization algorithm based on nature inspired strategies. Cuckoo search algorithm which is an algorithm based on nature inspired strategies provide optimized search value in local as well as in global usin levy flight in search space. Cuckoo search algorithm is based on the Obligate broad parasite behaviour of cuckoo birds ,according to which cuckoo will fail to complete their life cycle without the help of a host bird nest for reproduction. Cuckoo search algorithm uses parameter (p_a)discovery probability, alpha as the step size for search space and value of (n) as the host nest used for laying cuckoo eggs.

This paper is about cuckoo search algorithm ,improved cuckoo search ,adaptive cuckoo search and tested its performance on different benchmark functions .

A. Basic of cuckoo Search Algorithm

Cuckoo search algorithm works over three basic rules in which first is to lay one cuckoo chicks at a time in the host bird nest selected by random walk, second is selection of next cuckoo chick with highest fitness rate among all and the last is the discovery rate of cuckoo chicks by host bird which is fixed under p_a [0,1]. All these three steps are considered as major steps in every iteration of cuckoo search algorithm

Pseudo-code for Cuckoo search algorithm using levy flight as the random walk to get the next iteration host nests-

```
Objective function: f(x),   x = (x_1, x_2, ..., x_d);
Generate an initial population of n host nests;
While (t<MaxGeneration) or (stop criterion)
   Get a cuckoo randomly (say, i) and replace its
solution by performing Lévy flights;
   Evaluate its quality/fitness F_i
         [For maximization, F_i ∝ f(x_i) ];
   Choose a nest among n (say, j) randomly;
   if (F_i > F_j),
         Replace j by the new solution;
   end if
   A fraction (p_a) of the worse nests are abandoned
and new ones are built;
   Keep the best solutions/nests;
   Rank the solutions/nests and find the current
best;
   Pass the current best solutions to the next
generation;
end while
```

B. Basic of Levy Flight

Levy flight used to find the next host nest and next cuckoo chick which is to be selected is random having many values ,to get a specific global value with best current usage levy flight is used .levy is termed as heavy-tailed probability distribution for search space. Equation of levy flight for evaluating next cuckoo solution $Z_i(t+1)$ is-

$$y_j(s+1) = y_j^{(s)} + \alpha \oplus levy(\beta) \quad (1)$$

Where, α = Step size (α>0), in most cases we use α=1 and 1< β≤3.
Here the random step length is chosen by the levy distribution which is as follows-

$$Levy \sim v = s^{-}(1 < \beta \leq 3) \quad (2)$$

In this equation,
λ = value which is $1< \lambda \leq 3$
α = step length

C. Adaptive Cuckoo Search Algorithm

Adaptive cuckoo search does not use any random walk for search space to get the local maxima, as well as for global maxima and minima while cuckoo search uses levy flight which uses levy distribution for search space and increases complexity with more parameters .In adaptive cuckoo search less parameters are used, hence give better results in search space at global or local level in less time with better performance when applied on different benchmark function.
To get the step size in adaptive Cuckoo search algorithm –

$$step_i(t+1) = \left(\frac{1}{t}\right)^{\left|\frac{BF(t)-f_i(t)}{BF(t)-WF(t)}\right|} \quad (3)$$

Where,
T=Cuckoo search generation
BF=best fitness value in t^{th} generation
WF= worst fitness value in t^{th} generation
f_i = i^{th} nest fitness value of t^{th} generation
And the Adaptive Cuckoo search will give by-

$$X_i(t+1) = X_i(t) + rand * step_i(t+1) \quad (4)$$

D. Improved Cuckoo Search Algorithm

Improved Cuckoo search is an updated version of cuckoo search algorithm as it uses dynamic value of p_a and with increase in number of generations .We can say that using fixed value of parameters p_a and is the biggest drawback of cuckoo search algorithm. If the value of is large and p_a is small then iteration needs to be increased ,and if p_a is large and is small then it leads to poor and inefficient result.

1) $P_a(cn) = P_a ma - \frac{cn}{NI}(P_a ma - P_a mi)$
2) $\alpha(cn) = \alpha_{ma} e^{(c.cn)}$
3) $c = \frac{1}{NI} \ln\left(\frac{\alpha_{mi}}{\alpha_{ma}}\right)$

Table 1. Table of parameter values

Algorithm	Number of generation	Number of dimension	λ		p_a
Cuckoo search algorithm	1000	10	1.5	0.25	0.1
Improved Cuckoo search Algorithm	1000	10	1.5	(max)=0.5 (min)=0.01 (at start)	p_a(max)=0.5 p_a(min)=0.05 (at start)
Adaptive Cuckoo search Algorithm	1000	10	-	Dynamic	Dynamic

This table defines the different level of parameters used by Cuckoo search, Improved cuckoo search and adaptive cuckoo search. Improved cuckoo search is just having the starting standard value of p_a and and it will change as the number of generation changes .

Table 2. Benchmark functions

Name of Function	Search Space Value	Function Equation	Optimum value
Ackley's function	$[-32,32]^n$	$\min f_1 = 20 + e - 20exp\left(-0.2\sqrt{\frac{\sum_{i=1}^{N} X_i^2}{N}}\right) - exp\left(\frac{\sum_{i=1}^{N}\cos(2\pi X_i)}{N}\right)$	0
Rosenbrock's function	$[-100,100]^n$	$\min f_2 = \sum_{i=1}^{N}(100(X_{i-1} - X_i^2)^2 + (X_i - 1)^2)$	0
Griewank function	$[-10,10]^n$	$\min f_3 = \frac{1}{4000}\sum_{i=1}^{N} X_i^2 - \prod_{i=1}^{N}\cos\left(\frac{X_i}{\sqrt{i}}\right) + 1$	0
Rastrigrin function	$[-600,600]^n$	$\min f_4 = \sum_{i=1}^{N}(X_i^2 - 10\cos(2\pi X_i) + 10)$	0
Sphere function	$[-100,100]^n$	$\min f_5 = \sum_{i=1}^{N} X_i^2$	0

Table 3. Performance evaluation of Cuckoo Search, Improved Cuckoo Search and Adaptive Cuckoo search Algorithms at N=10

Function name	Algorithm	Iteration	Best value	Mean	Standard Deviation
Ackley's function	CS ICS ACS	1000	3.1724e-08 2.1651e-11 19.1643	2.4007e-06 6.5468e-07 20.5253	1.1978e-06 1.5947e-07 0.2358
Rosenbrock's function	CS ICS ACS	1000	1.8759e+00 9.8653e+00 2.2898e+08	4.0384e+01 2.6678e+01 5.9090e+07	3.5250e+01 1.3697e+01 5.4964e+07
Griewank'sfunction	CS ICS ACS	1000	1.2824e-02 2.7491e-03 28.0962	5.3369e-02 3.4795e-02 303.3699	2.1703e-02 1.6791e-02 435.4642
Rastrigrin Function	CS ICS ACS	1000	2.4935e+00 1.4728e+00 583.9006	5.8173e+00 3.1597e+00 268.9032	2.2131e+00 9.1871e-01 79.6039
Sphere function	CS ICS ACS	1000	4.9826e-18 2.3482e-25 6.4509e+04	2.5086e-16 4.2599e-22 3.3969e+04	3.5572e-16 1.1657e-21 8.9961e+03

Table 4 Performance evaluation of Cuckoo Search, Improved Cuckoo Search and Adaptive Cuckoo search Algorithms at N=30

Function name	Algorithm	Iteration	Best value	Mean	Standard Deviation
Ackley's function	CS ICS ACS	3000	5.7283e-07 7.0179e-10 20.5336	2.0926e+00 3.0880e-01 18.5015	8.4421e-01 5.9632e-01 0.2409
Rosenbrock's function	CS ICS ACS	3000	1.8759e+00 9.8653e+00 2.2753e+08	4.0384e+01 2.6678e+01 1.1098e+07	4.0384e+01 2.6678e+01 5.4902e+07
Griewank's function	CS ICS ACS	3000	1.2824e-02 2.7491e-03 583.1773	5.3369e-02 3.4795e-02 272.1443	2.1703e-02 1.6791e-02 82.5165
Rastrigrin Function	CS ICS ACS	3000	2.0423e+01 1.1939e+01 2.2975e+08	3.6513e+01 2.2296e+01 5.1533e+07	9.2702e+00 4.1242e+00 5.3263e+07
Sphere function	CS ICS ACS	3000	1.2421e-15 2.9807e-22 6.4619e+04	7.3248e-13 4.1015e-20	1.3432e-13 1.1279e-20 9.2464e+03

II. CONCLUSION

In this paper, we have tested adaptive Cuckoo search algorithm, cuckoo search algorithm on different five different benchmark function, Ackley's, Rosenbrock's, Griewank's, Rastrigrin and Sphere function listed from f_1-f_5 the results shows that improved cuckoo search produced better result in comparison cuckoo search algorithm giving better performance and good efficiencey also improved cuckoo search produces significantly better result and l global solution in less time.

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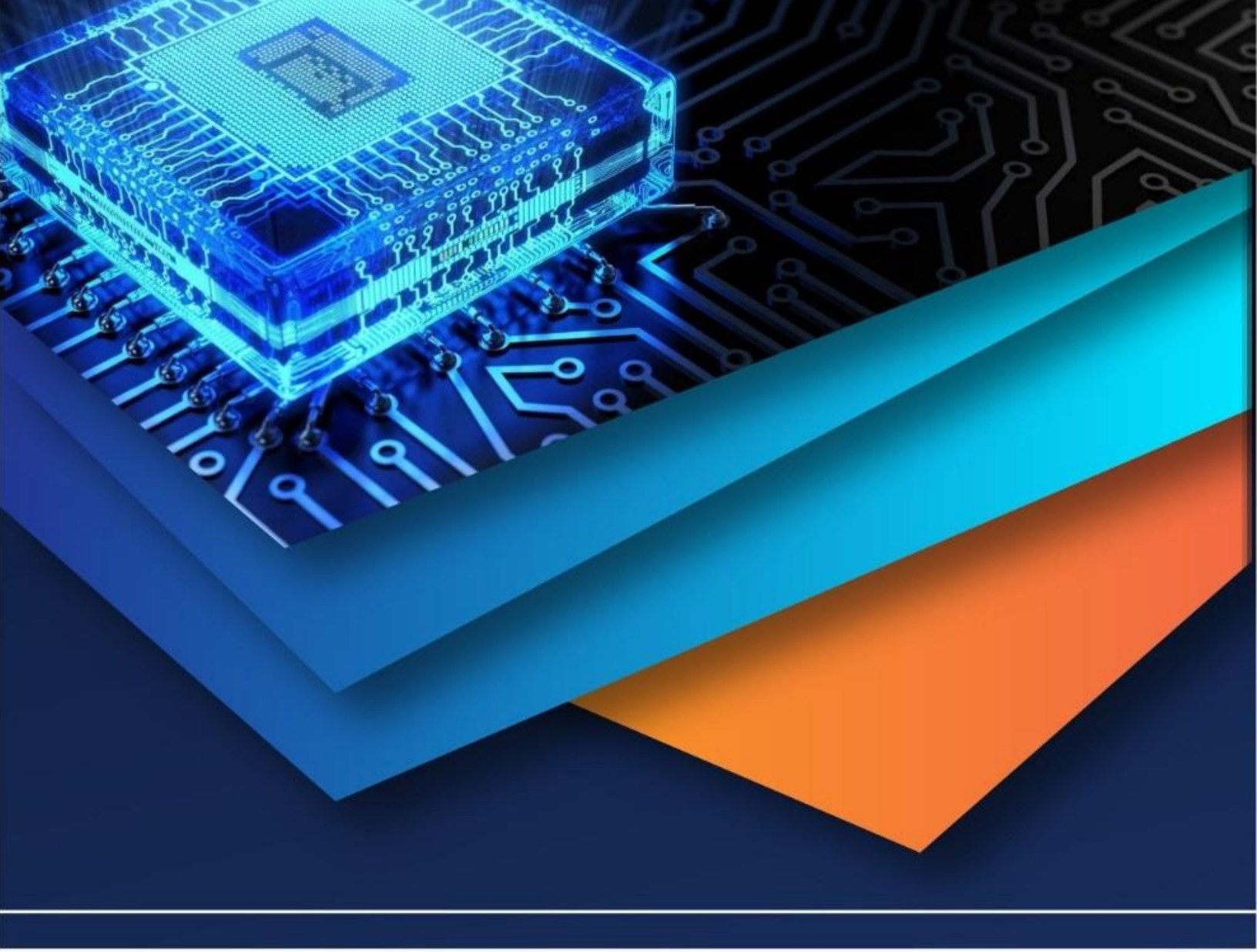

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