Performance Analysis between PSO and Deer Algorithms (DA)

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ABSTRACT

Metaheuristic optimization Algorithms like PSO and Deer Algorithm can solve optimization problems very effectively. Proposed algorithms show their best solution for the converages the optimum solutions. In this paper we comparing particle swarm algorithm with newly introduced Deer Algorithm. Benchmark problems are used to check efficiency, robustness, convergence, stability of the algorithms.

Keywords: Metaheuristic, Particle Swarm Optimization, Deer Algorithm

1.INTRODUCTION

Nature inspired statistics metaheuristic optimization [5][11] methods such as Particle Swarm Optimization (PSO)[1],Genetic algorithm(GA)[6]], Firefly algorithm (FA)[7] , Bat algorithm (BA)[9], Cuckoo Search (CS)[20], ant colony optimization Algorithm (ACO), Honey Bee Algorithm[8], Artificial Bee Colony (ABC), wolf pack algorithm[12], Hunting Search[13], Group Area Search: A Novel Nature-Inspired Optimization Algorithm [14] motivate us to work on behaviour of animal such as Deer who live in group known as herd.

In this paper the new population based metaheuristic algorithms red deer has been proposed. This algorithm have 3 operators to simulate the Deer's characteristics: Following and growning, thrashing and mating. This algorithm is inspired by social behaviour of deer herd like schooling in PSO and Bat Algorithms for growning and many similarities with evolutionary computation techniques such as Genetic Algorithms (GA) for threshing and mating.

Particle Swarm Optimization algorithm

Particle Swarm Optimization algorithm (PSO) is proposed by James Kennedy and Russell Eberhart in 1995 [1]. PSO is one of the most used EAs. It is motivated by social behaviour of organisms such as bird flocking and fish schooling [1]. The PSO algorithm, while making adjustment towards "local" and "global" best particles, is similar to the crossover operation used by genetic algorithms[2]. Particle swarm optimization is a population -based stochastic algorithm which is inspired by the migratory behaviour in the nature that starts with an initial population of randomly generated particles. In PSO, each particle in the population (swarm) flies towards its previous best position and the global best position. Although the mechanism of this motion can result in a fast convergence, it suffers from the premature convergence problem, which means that it can be easily trapped into local minima when solving multimodal problems [11]. Although the convergence speed of PSO is high due to the fast information exchange between the solution vectors, its diversity decreases very quickly in the successive iterations resulting in a suboptimal solution [11].

Deer Algorithm

Deer algorithms is population based metaheuristic algorithms like Red deer proposed by Fathollahi Fard in 2016[16]. Deer is Evolutionary Algorithm. This algorithm have three operators to simulate the Red Deer's characteristics: Growning, Thrashing and Mating behaviour.

Inspiration

Deer are the most socially inclined of wild life which display high levels of socialism. Deer always lived in group known as herd and moving to search for food in herd. If there is any danger situation then they move fast and change the location. Male deer known as known as “Stage” and female deer known as “hinds”. For the reproduction system of stage Deer attract “hind” by growning known as growning. After growing there are many hinds are collected, then there is threshing (thrashing) between male (Stage) and many female hinds. Best one of them is selected for the mating. This algorithm is inspired by social behaviour of deer herd like schooling and many similarities with evolutionary computation techniques such as Genetic Algorithms (GA).

Initialization

A group of deer are randomly wondering for searching food in an area. All the deer always be in group so they follow each other. The effective one is to follow the deer which is nearest to the food because deer always
be in group known as herd.

Movement for food

DA learned from the scenario and used it to solve the optimization problems. In DA, each single solution is a "Deer" in the search space. We call it "Deer". All of Deer have fitness values which are evaluated by the fitness function to be optimized, and have velocities which direct the moving deer. The deer move through the problem space by following the current optimum.

DA is initialized with a group of random deer (solutions) and then searches for optima by moving generations.

The Deer Algorithms work like

1. Random generation of an initial population of Deer
2. Reckoning of a fitness value for each subject. It will directly depend on the distance to the optimum.
3. Reproduction of the population based on fitness values.
4. If requirements are met, then stop. Otherwise go back to

Deer Mutation

Stage Deer attract “hind” by growning known as growning. After growing their are many hinds are collected, then there is threshing (thrashing) between male(Stage) and many female hinds. Best one of them is selected for the mating

1. *Deer Reproduction*

When competing for access to females, males ‘display’ by groaning, thrashing their antlers and by walking alongside their opponent. Thrashing occurs if both stags are evenly matched and involves wrestling and clashing of antlers.

Hind give birth to a single fawn after a gestation period of 31 – 32 weeks (around 8 months). The Fallow hind usually leaves the herd to search for a private hiding place to give birth. After the fawn is born, usually in May or June, it remains in its hiding place (in bushes or undergrowth). The hind returns every four hours to feed it until it is about four months old, when it joins the herd. The fawn is weaned after 7 – 9 months. The life span of the Deer is about 12 – 16 years.

Proposed Deer algorithm[16]

1. Initialization

The DA is a population based meta heuristic algorithm in which first step is randomly generate the initial population Npop over the solution space known as “deer” in a Nvar dimensional optimization problem. We select the best Deers to N male and the rest of to N hind. Deer’s mating is developed.

$$\text{Deer}=[X_1,X_2, X_3,X_4.................., X_{nvar}] \qquad (1)$$

$$\text{Value}=f(\text{Red Deer})=f(X_1,X_2, X_3,X_4....., X_{nvar}) \qquad (2)$$

2. G**rowning male deers**

In this step, the male deers are trying to increase their grace by growning. Its counterpart of solution in local searches near them. In fact, we permit every male deers to change his position f

3. **Select γ percent of best male Deers as male command**

$$N.male.Com=\text{round}\{ \square .N_{male} \} \qquad (3)$$

$$N.stag=N_{male}-N.male.Com \qquad (4)$$

4. Fight between male commanders and stags.We let for each commander males fight with stags randomly. And select them after thrashing if the objective function is better than the prior ones.

5. **Form harems**

$$V_n=v_n-\max\{v_i\} \qquad (5)$$

$$Pn=\left| \frac{Vn}{\sum_{i=1}^{N,male.com} Vi} \right| \qquad (6)$$

$$N.herem_n= \text{round}\{p_n.\ N_{hind}\} \qquad (7)$$

6. Mate male commander of harem with α percent hinds in his harem.

$$N.harem^{mate}{}_{n}=round\{\alpha.N.heram_{n}\} \quad (8)$$

7. Mate male commander of harem with β percent hinds in another harem.

$$N.harem^{mate}{}_{n}=round\{\beta.N.heram_{n}\} \quad (9)$$

8. Mate stag with the nearest hind In this step, for each stags, they are mating with closest hind. In breeding season, the male Deers prefer to follow the handy hind; this hind may be his favourite hind among all hinds. This hind maybe in his harem or habituates in another harem

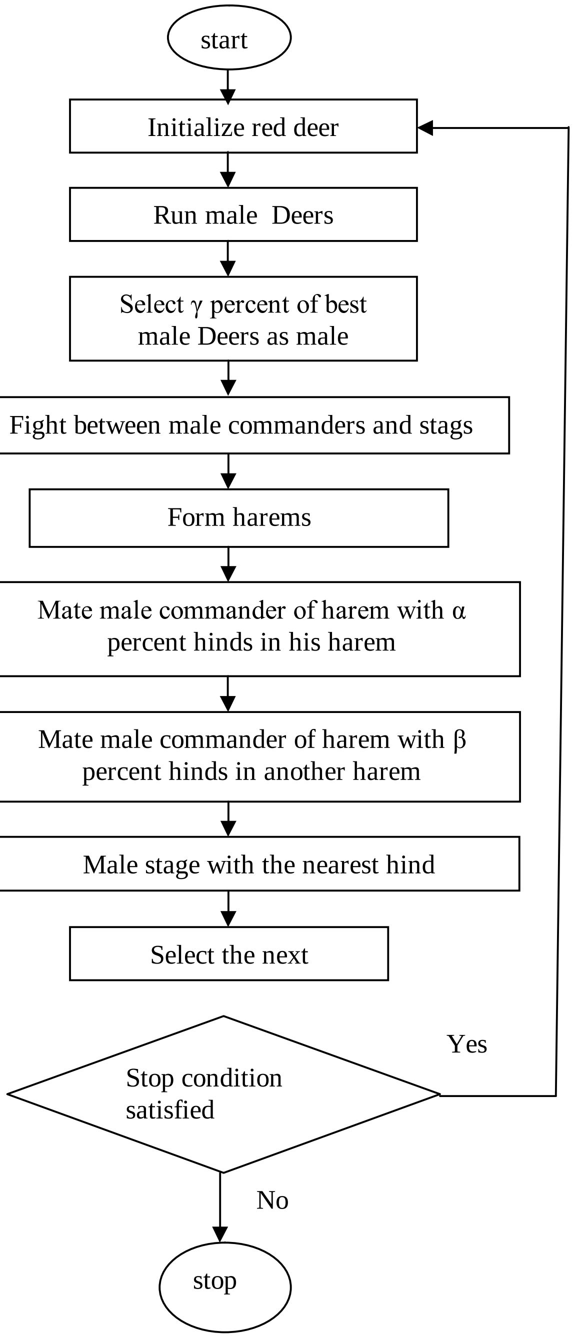
$$d_i=\left(\sum_{j\in J}\left(stag_j - hind_j^i\right)^2\right)^{1/2} \quad (10)$$

9. Select the next generation we select the next generation of male RDs as best solutions and for choose hinds for next generation with tournament selection or roulette wheel selection or each evolutionary mechanism for selection with fitness.

10. Convergence The stopping condition are the number of iteration, the best solution found and a time interval are calculated.

Pseudo Code of Deer Algorithm

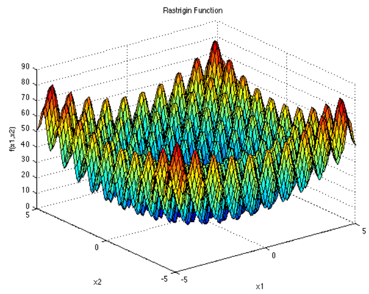
```
For each deer
        Initialize  n Deer to random position
End
for each n Deer population
  calculate initial best position
  calculate initial best cost
end
for each n Deer population
for j=1:nMale Deer
 if Male D(j).Cost> MaleDN(j).Cost
 select best male
 end
 end
for each Iteration i=1 to n
for j=1:nMaleD
select best position for growning
select best cost for growning
collect hinds
end
end
for j=1: nMaleD
fight with hinds
select best hind position
select best hind cost
end
for j=1: nMaleD
mate male hinds with selected hinds
update global best position
```



Experimental Result

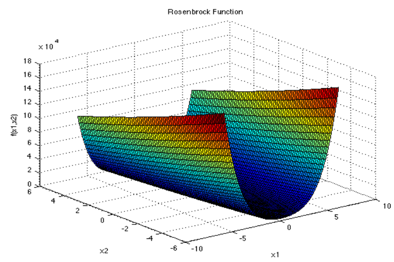
To evaluate the performance of Deer algorithm , it was tested on benchmark function and DA is compare with traditional PSO algorithm. Some unimodel and multimodel Benchmark function were considered for experiment[15].

Rastrigin - The Rastrigin function is multimodel function. The Rastrigin function has several local minima and one global minima. It is shown in the plot above in its two-dimensional form[17].



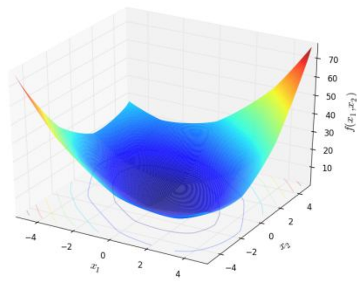
$$f(\mathbf{x}) = 10d + \sum_{i=1}^{d} \left[x_i^2 - 10\cos(2\pi x_i)\right]$$

Rosenbrock- The Rosenbrock function, look like the Valley or Banana function, is a popular test problem for gradient-based optimization algorithms. This function is unimodal, and the global minimum lies in a narrow, parabolic valley. However, even though this valley is easy to find, convergence to the minimum is difficult (Picheny et al., 2012) [17].



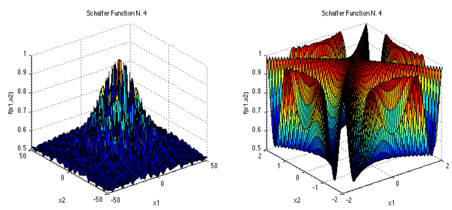
$$f(\mathbf{x}) = \sum_{i=1}^{d-1} \left[100(x_{i+1} - x_i^2)^2 + (x_i - 1)^2\right]$$

Bukin06-This is a multimodal minimization problem defined as follows: Here, n represents the number of dimensions and $x_i \in [-50, 50]$ for $i = 1, ..., n$.[18]



$$f_{\text{BartelsConn}}(\mathbf{x}) = |x_1^2 + x_2^2 + x_1 x_2| + |\sin(x_1)| + |\cos(x_2)|$$

Schaff4 [17][18]

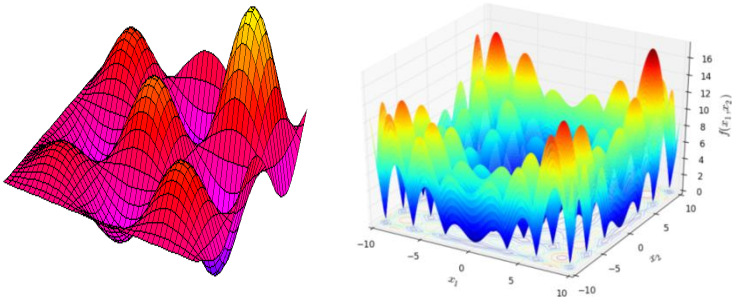


$$f(\mathbf{x}) = 0.5 + \frac{\cos\left(\sin(|x_1^2 - x_2^2|)\right) - 0.5}{\left[1 + 0.001(x_1^2 + x_2^2)\right]^2}$$

Alpline[18]

This function is interesting for testing the search of an extrema for the following reasons:

- there are as many local extrema we want, just by increasing x_{max},
- there is just one global extrema,
- the solution can easily be directly computed.



The 2D alpine function.

This function is defined by

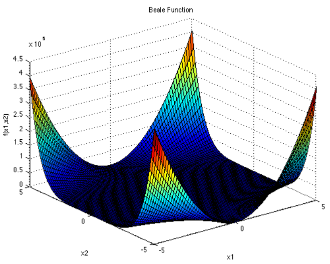
$$z = f(x_1, \ldots, x_D) = \sin(x_1)\ldots\sin(x_D)\sqrt{x_1 \ldots x_D}, (x_1, \ldots, x_D) \in [0, x_{max}]^D$$

This class defines the Alpine 1 global optimization problem. This is a multimodal minimization problem defined as follows:

$$f_{\text{Alpine01}}(\mathbf{x}) = \sum_{i=1}^{n} |x_i \sin(x_i) + 0.1 x_i|$$

Here, n represents the number of dimensions and $x_i \in [-10, 10]$ for $i = 1, ..., n$.

Beale - The Beale function is multimodal, with sharp peaks at the corners of the input domain[18].

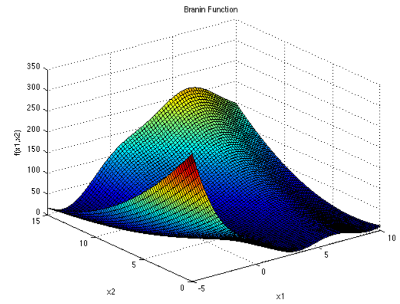


$$f(\mathbf{x}) = (1.5 - x_1 + x_1 x_2)^2 + (2.25 - x_1 + x_1 x_2^2)^2 + (2.625 - x_1 + x_1 x_2^3)^2$$

The function is usually evaluated on the square $x_i \in [-4.5, 4.5]$, for all i = 1, 2.

Brainine

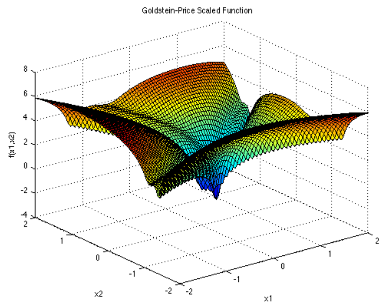
The Branin, or Branin-Hoo, function has global minima. The recommended values of a, b, c, r, s and t are: a = 1, b = $5.1/(4\pi^2)$, c = $5/\pi$, r = 6, s = 10 and t = $1/(8\pi)$ [18].



$$f(\mathbf{x}) = a(x_2 - bx_1^2 + cx_1 - r)^2 + s(1-t)\cos(x_1) + s$$

Goldstein-price function

The Goldstein-Price function has several local minima [18]



$$f(\mathbf{x}) = \frac{1}{2.427}\left[\log\left(\left[1+(\bar{x}_1+\bar{x}_2+1)^2\left(19-14\bar{x}_1+3\bar{x}_1^2-14\bar{x}_2+6\bar{x}_1\bar{x}_2+3\bar{x}_2^2\right)\right]\right.\right.$$
$$\left.\left.\left[30+(2\bar{x}_1-3\bar{x}_2)^2\left(18-32\bar{x}_1+12\bar{x}_1^2+48\bar{x}_2-36\bar{x}_1\bar{x}_2+27\bar{x}_2^2\right)\right]\right)-8.693\right], \text{ where}$$

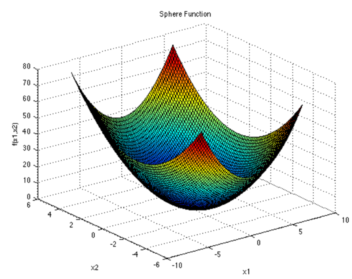
$$\bar{x}_i = 4x_i - 2, \text{ for all } i = 1, 2$$

Powell[17]

$$f(x) = \sum_{i=1}^{d/4}\left[(x_{4i-3}+10x_{4i-2})^2 + 5(x_{4i-1}-x_{4i})^2 + (x_{4i-2}-2x_{4i-1})^4 + 10(x_{4i-3}-x_{4i})^4\right]$$

Sphere

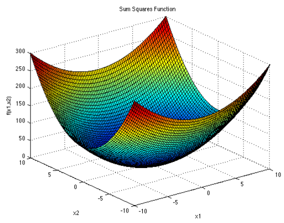
The Sphere function has d local minima except for the global one. It is continuous, convex and unimodal. The plot shows its two-dimensional form [18].



$$f(\mathbf{x}) = \sum_{i=1}^{d} x_i^2$$

Sumsquare

The Sum Squares function, also referred to as the Axis Parallel Hyper-Ellipsoid function, has no local minimum except the global one. It is continuous, convex and unimodal. It is shown here in its two-dimensional form[18].



$$f(\mathbf{x}) = \sum_{i=1}^{d} i x_i^2$$

Experimental Parameters

To evaluate performance of Deer Algorithm , In all cases population is set to 100 for PSO and DA. The dimension is 30. Maximum Iteration are 100 for PSO and DA. Stopping criteria are maximum number of function evaluation 150000.

In particle swarm optimization parameters are considered as Maximum Number of Iterations are 100,population size of particle are considered as 100, Inertia Weight w=1, Inertia Weight Damping Ratio wdamp=1 and Personal Learning Coefficient c1=1.5,and Global Learning Coefficient=2.0.The dimensions of the problems are set to be 30, for every population the results are recorded and presented in two different ways viz. a) best solution i.e global minimum b) elapsed time

In Deer algorithm parameters are considered as Maximum Number of Iterations are 100,population size of particle are considered as 100, rate of thrashing =0.5, rate of mating=0.8; the percent of mating in the one harems alpha 0.9; the percent of mating in other harems betta=0.4; the percent of male commanders gamma=0.7; rate of allocation is anii=1;

The experiment was conducted in Matlab considering Unimodel and multimodel functions with several local minima. Here we were introduce most suitable function for DA and PSO

Table 1 Comparative Result on Benchmark function

Function Name	PSO		DA	
	Best cost	Elapsed time	Best cost	Elapsed time
Rosenbrock	6.91	7.02	6.81	8.41
Rastrigin	2.84	3.42	0	5.02
Bukin06	0.14	3.49	0.11	6.04
Schaff4	0.52	3.80	0.52	6.38
alpline	0.00	3.88	0.00	5.84
Pathology	0.78	4.91	0.50	8.82
Beale	1.46	3.30	1.07	6.92
Brainin	0.39	3.57	0.39	6.09
Gold	3	3.79	3	6.09
Powell	5.36	3.50	0.00	6.14
Spheref	4.33	3.61	1.16	5.15
Sumsqu	6.20	4.81	1.72	5.87

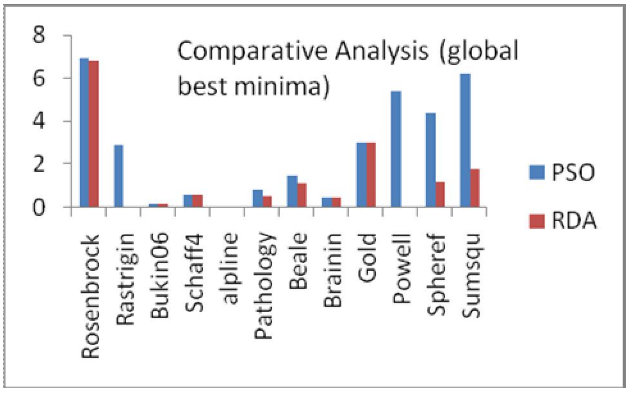


Fig 1: Comparison between PSO and DA in terms of best solution of the benchmark function

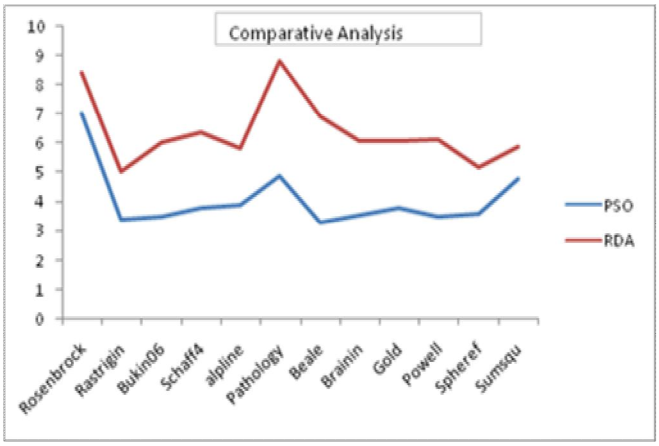


Fig 2: Comparison between PSO and DA in terms of elapsed time

Algorithm Complexity

We were compare particle swarm optimization and Deer algorithm both have Algorithm complexity same i.e $O(n^2)$. It shows that both Algorithm are similar, simple and easy to use.

Application of Deer Algorithms

Application of Deer algorithm are Travelling salesman Problem, Scheduling.

2.CONCLUSION

Deer algorithm is constructed based on their reproduction system such as growning, thrashing, mating which help to found best possible solution for benchmark function. The result provided by Deer algorithm provide superior result to achieve global optima. Time required to run DA algorithm is slower than PSO due to many parameter in DA such growning, thrashing, mating it require time to execute. The overall performance of DA is best on benchmark suite including unimodel, multimodel function with several local minima.

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