

## Using Black Holes Algorithm in Discrete Space by Nearest Integer Function

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### ABSTRACT

In this paper we Using Black Holes Algorithm in Discrete Space by Nearest Integer Function. Black holes algorithm is a Swarm Algorithm inspired of Black Holes for Optimization Problems. We suppose each solution of problem as an integer black hole and after calculating the gravity and electrical forces use Nearest Integer Function. The experimental results on different benchmarks show that the performance of the proposed algorithm is better than PSO (Binary Particle Swarms Optimization), and GA (Genetic Algorithm).

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## 1. INTRODUCTION

Over the last decades, there has been a growing interest in algorithms inspired by the observation of natural phenomena [1]. These algorithms are found to be more powerful than the conventional methods that are based on formal logics or mathematical programming [2]. There are many ways to classify metaheuristic algorithms, e.g. nature inspired versus others; population based versus single point, etc. [3].

The PSO algorithm is one of the modern evolutionary algorithms. Kennedy and Eberhart first proposed this algorithm. PSO was developed through simulation of a simplified social system, and has been found to be robust in solving continuous non-linear optimization problems [4]. The league championship algorithm (LCA) is an algorithm originally proposed for unconstrained optimization which tries to metaphorically model a League championship environment wherein artificial teams play in an artificial league for several weeks [5]. Cuckoo search is an optimization algorithm that inspired by lifestyle of a bird. Special characteristics of cuckoos in egg laying and breeding had been the basic motivation for development of this new optimization algorithm. Each individual in the algorithm has a habitat around which she starts to lay eggs [6]. In nature, flowing water drops are observed mostly in rivers, which form huge moving swarms. The paths that a natural river follows have been created by a swarm of water drops. One feature of a water drop flowing in a river is its velocity. It is assumed that each water drop of a river can also carry an amount of soil. Therefore, the water drop is able to transfer an amount of soil from one place to another place in the front. Based on these observations, the Intelligent Water Drops (Shah-Hosseini, 2007) have been introduced [7]. Artificial Fish Swarm Algorithm (AFSA) is a swarm intelligence optimization algorithm based on animal behavior, easy to implement [8].

The rest of this paper is organized as follows: The next section gives a review about black holes algorithm. The proposed algorithms (Using Black Holes Algorithm in Discrete Space by Nearest Integer

Function) introduced in section 3. In section 4 the computational and experimental results are presented to evaluate the performance of the proposed method. Finally, in Section 5 includes conclusions and discussions.

## 2. BLACK HOLES ALGORITHM

The black hole algorithm proposed in the paper [9] by Nemati et al. In this algorithm at first generated a random population a then evolve it in the generations to earn best solution. In this algorithm initialized step is production of a number of random black holes as initial solution. Each of this black holes has own position, mass and electrical charge. The name of this step is called big bang. Each of black holes is a solution for the problem.

$$black\ hole_i = \begin{cases} Position = X \\ mass = m \\ charged = q \end{cases} \quad i = 1, 2, \dots, N \quad (1)$$

At second step, fitness evaluated for each of these black holes as formula (2), which  $f$  is Cost function and determine the best black hole in the population and call it **global best**.

$$fitness_{i-th} = f(black\ hole_i) \quad i = 1, 2, \dots, N \quad (2)$$

In third step, evaluated the new position of the each black hole by calculating the forces .In algorithm each black hole attracted to the global best by gravity force and attracted to the local best position by the Coulomb's law, In the other words we assume FG (gravity force) for the global search and FQ (electricity force) for the local search. FG and FQ are calculated by (3) and (4) formulas.

$$Fg_i = G \frac{m_{gbest} * m_i}{r^2} \quad i = 1, 2, \dots, N \quad (3)$$

$$Fq_i = k \frac{q_{lbest} * q_i}{r^2} \quad i = 1, 2, \dots, N \quad (4)$$

Where  $Fg$  is gravitational force,  $Fq$  is electrical force,  $m_{gbest}$  is mass of global best black hole, and  $q_{lbest}$  is charge of local best black hole.  $G$  and  $K$  are constant number. When  $Fg$  and  $Fq$  were calculated, then we earn new position of the black holes by formula (5).

$$X_i(t + 1) = X_i(t) + random1 * Fg + random2 * Fq \quad i = 1, 2, \dots, N \quad (5)$$

Where  $X_i(t + 1)$  and  $X_i(t)$  are the position of  $i$ -th black hole at iteration  $t+1$  and  $t$ , respectively. and  $Fg$  is gravitational force,  $Fq$  is electrical force. And also  $random1$ ,  $random2$  are random number between  $[0,1]$ .

The algorithm also used of Hawking radiation as. At this step is the same mutation step in genetic algorithm. by hawking radiation the algorithm escape from trapping in local optimums. In this step, by randomly we changed the position of black holes. With this work the algorithm escape from trapping in local optimums.

## 3. PROPOSED METHOD

The nearest integer function, also called nint or the round function, is defined such that nint(x) is the integer closest to x. While the notation  $\lfloor x \rfloor$  is sometimes used to denote the nearest integer function (Hastad et al. 1988), this notation is rather cumbersome and is not recommended. Also note that while  $\lfloor x \rfloor$  is sometimes used to denote the nearest integer function,  $\lfloor x \rfloor$  is also commonly used to denote the floor function  $\lfloor x \rfloor$ , so this notational use is also discouraged. Since the definition is ambiguous for half-integers, the additional rule that half-integers are always rounded to even numbers is usually added in order to avoid statistical biasing. For example, nint(1.5)=2, nint(2.5)=2, nint(3.5)=4, nint(4.5)=4, etc. Graph of nearest integer function showed in the figure 1.

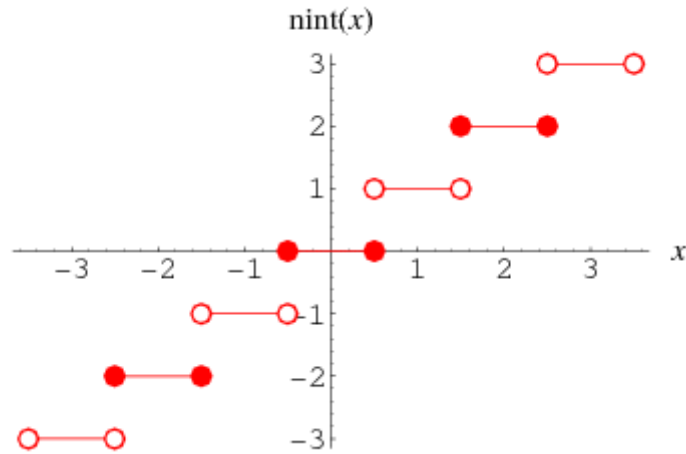


Figure 1. Nearest integer function ( $nint(x): R \rightarrow Z$ )

In the propose method we act nearest integer function to the electrical and gravity forces.

$$nint(F_g) = \lfloor F_g \rfloor \quad (6)$$

$$nint(F_q) = \lfloor F_q \rfloor \quad (7)$$

$$X_i(t + 1) = X_i(t) + random1 * nint(F_g) + random2 * nint(F_q) \quad i = 1, 2, \dots, N \quad (8)$$

Based on the above the main steps in the proposed binary black hole algorithm are summarized as follow Pseudo-code:

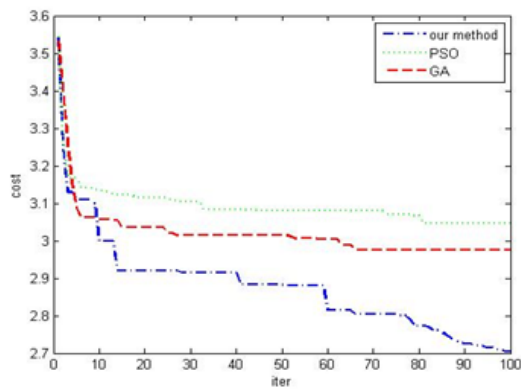
**Input:** objective function  
**Output:** optimal solution  
Initialize a population of black holes with random locations in the search space  
**While** (termination criteria satisfy) **do**  
    For each black hole, evaluate the objective function  
    Select the global best black hole that has the best fitness value  
    Calculate the Eq. (6), (7)  
    Change the location of each black hole according to Eq. (8)  
    Do Hawking radiation  
**End of while**

#### 4. THE EXPERIMENTAL RESULTS

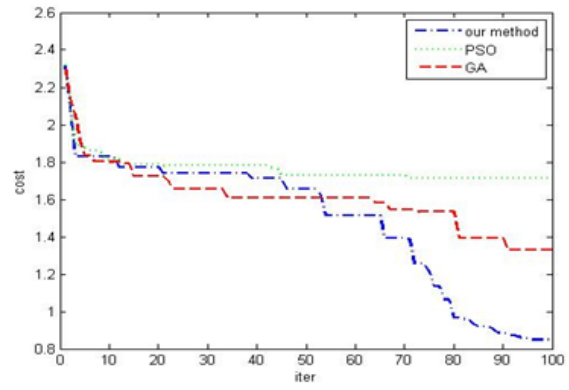
In this section the Black Holes Algorithm in Discrete Space by Nearest Integer Function is impalement with 4 functions. Benchmark function and properties is show on table 1. The performance of the proposed algorithm is compared against PSO (Binary Particle Swarms Optimization), and GA (Genetic Algorithm). The experiments for each function run for 50 times and average of result is reported. In figures 2 for better distinction of four algorithms the Y-axis (fitness) is on logarithmic scale.

Table 1. Benchmark Function

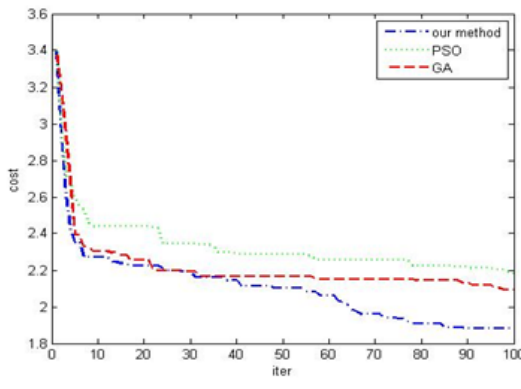
F	Eq1	Dimensions	Min
$f_1$	$f_1(x) = \sum_{i=1}^n [x_i^2 - 10\cos(2\pi x_i) + 10]$	10, 100	0
$f_2$	$f_2(x) = \sum_{i=1}^n [(x_i + 0.5)^2]$	10, 100	0
$f_3$	$f_3(x) = \sum_{i=1}^n [100(x_{i+1} - x_i^2)^2 + (x_i - 1)^2]$	10, 100	0
$f_4$	$f_4(x) = \sum_{i=1}^n  x_i  + \prod_{i=1}^n  x_i $	10, 100	0



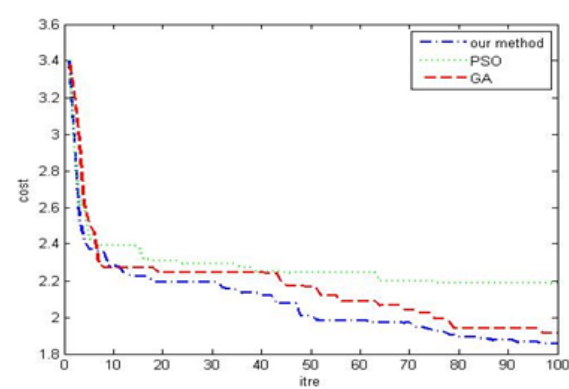
F1-d1



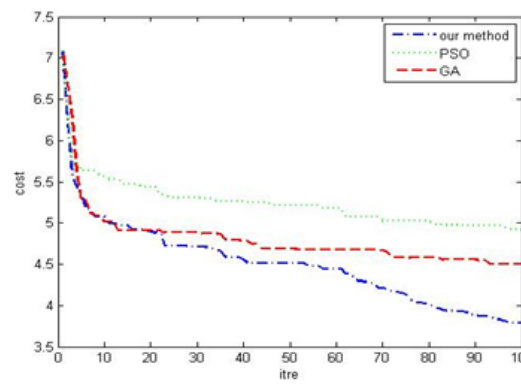
F1-d2



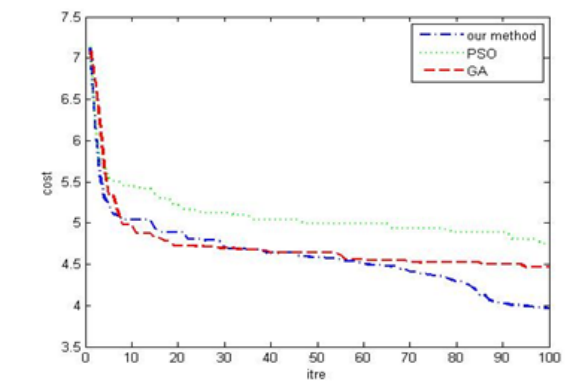
F2-d1



F2-d2



F3-d1



F3-d2

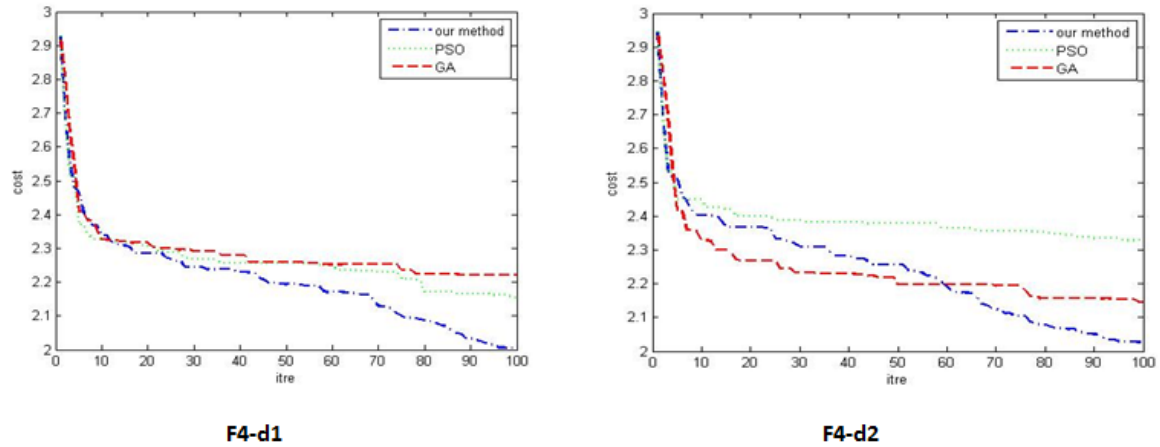


Figure 2. Convergence performance of Black Holes Algorithm in Discrete Space by Nearest Integer Function and PSO and GA on 4 Benchmark function (10D and 100D) - X-axis is generation and Y-axis is fitness on logarithmic scale

Table 2. Global optimization results for function 1 ( $f_1$ )

Algorithm	Population size	Dimension	Iteration	Best Answer
GA	100	100	100	946.2085
PSO	100	100	100	1.1101e+003
<b>Our method</b>	100	100	100	<b>506.0040</b>
GA	1000	10	100	21.2510
PSO	1000	10	100	51.8605
<b>Our method</b>	1000	10	100	<b>7.0346</b>

Table 3. Global optimization results for function 2 ( $f_2$ )

Algorithm	Population size	Dimension	Iteration	Best Answer
GA	100	100	100	124
PSO	100	100	100	152
<b>Our method</b>	100	100	100	<b>76</b>
GA	1000	10	100	82
PSO	1000	10	100	153
<b>Our method</b>	1000	10	100	<b>72</b>

Table 4. Global optimization results for function 3 ( $f_3$ )

Algorithm	Population size	Dimension	Iteration	Best Answer
GA	100	100	100	3.1729e+004
PSO	100	100	100	8.2664e+004
<b>Our method</b>	100	100	100	<b>6.1180e+003</b>
GA	1000	10	100	2.9035e+004
PSO	1000	10	100	5.5892e+004
<b>Our method</b>	1000	10	100	<b>9.2330e+003</b>

Table 5. Global optimization results for function 4 ( $f_4$ )

Algorithm	Population size	Dimension	Iteration	Best Answer
GA	100	100	100	166.7986
PSO	100	100	100	142.5525
<b>Our method</b>	100	100	100	<b>100.9256</b>
GA	1000	10	100	139.7662
PSO	1000	10	100	212.7877
<b>Our method</b>	1000	10	100	<b>106.0410</b>

## 5. CONCLUSION

In this paper we Using Black Holes Algorithm in Discrete Space by Nearest Integer Function. Black holes algorithm is a Swarm Algorithm inspired of Black Holes for Optimization Problems. We suppose each

solution of problem as an integer black hole and after calculating the gravity and electrical forces use Nearest Integer Function. The experimental results on different benchmarks show that the performance of the proposed algorithm is better than PSO (Binary Particle Swarms Optimization), and GA (Genetic Algorithm).

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