Evolutionary Algorithms (EA)

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Contents

List of Figures

Chapter 1

Differential Evolution (DE)

1.1 Story

1.2 Pseudo code

1.3 Flowchart

Chapter 2

Evolutionary Strategy (ES)

2.1 Story

2.2 Pseudo code

2.3 Flowchart

Chapter 3

Cuckoo Search (CS)

3.1 Story

3.2 Pseudo code

3.3 Flowchart

Chapter 4

Artificial Bee Colony (ABC)

4.1 Story

4.2 Pseudo code

4.3 Flowchart

Chapter 5

Particle Swarm Optimization (PSO)

5.1 Story

5.2 Pseudo code

5.3 Flowchart

Chapter 6

Whale Optimization Algorithm (WOA)

6.1 Story

6.2 Pseudo code

6.3 Flowchart

Chapter 7

Grey Wolf Optimization (GWO)

7.1 Story

7.2 Pseudo code

7.3 Flowchart

Chapter 8

Flower Pollination Algorithm (FPA)

8.1 Story

8.2 Pseudo code

8.3 Flowchart

Chapter 9

Firefly Algorithm (FA)

9.1 Story

9.2 Pseudo code

9.3 Flowchart

Chapter 10

Black Hole Algorithm (BHA)

10.1 Story

BHA [2, 3] heuristic approach was introduced in 2012. The analogy is to create a random population of stars in the search space, the one with the best fitness value is considered as the black hole. The black hole gives a direction for every star's movement in all iterations. The stars are moving towards the black hole in a random way. After movement if the fitness value of a star is better than the fitness value of the black hole, then this star becomes the black hole. Furthermore another mechanism is involved to make a balance between exploration and exploitation, according to that if a star crosses the event horizon (defined distance from the black hole) then the black hole swallows it. Technically the star loose it's actual position and being redistributed randomly in the search space. Hence a new star is born to keep the population constant.

Let $X = \{x_1, x_2, \ldots, x_N\}$ population of stars, where N is the population size and $x_i \in \mathbb{R}^D$. $f : \mathbb{R}^D \to \mathbb{R}^1$ is the fitness function and $fitness_i = f(x_i)$ is the fitness value of x_i.
Movement of stars towards the black hole:

$$x_i(t+1) = x_i(t) + rand * (x_{BH} - x_i(t)) \tag{10.1}$$

where $x_i(t)$ is the location of the ith star at iteration t, and x_{BH} is the black hole. $x_{BH} : fitness_{BH} = \min_{i=1,\ldots,N} f(x_i)$ (min because of minimization problem). $rand \in U(0,1)$, where U stands for uniform distribution.
Radius of the event horizon is calculated as follows:

$$EventHorizon = \frac{fitness_{BH}}{\sum_{i=1}^{N} fitness_i} \tag{10.2}$$

10.2 Pseudo code

Algorithm 1: Black Hole Algorithm

```
begin
    Set N: population size, T: number of iterations
    Initialize random population of stars X = {x_1, x_2, ..., x_N},
    Calculate fitness values fitness_i, determine the black hole x_BH,
    Calculate EventHorizon by Equation 10.2
    while t <= T or Stopping criteria not met do
        for i ← 1 to N do
            Update location of star x_i by Equation 10.1
            Check search space
            Calculate fitness_i = f(x_i)
            if fitness_i < fitness_BH then
                x_BH = x_i
                fitness_BH = fitness_i
                Calculate EventHorizon by Equation 10.2
            end
            else
                if ||x_BH − x_i|| < EventHorizon then
                    Reinitialize x_i randomly within the search space
                end
            end
        end
        Check Stopping Criteria
        t = t + 1
    end
end
```

Bibliography

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