Evolutionary Algorithms (EA)

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Black Hole Algorithm (BHA)

10.1 Story

BHA [1, 2] 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 cross 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 $X = \{x_1, x_2, \ldots, x_N\}$,
  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 $i \leftarrow 1$ *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

10.3 Flowchart

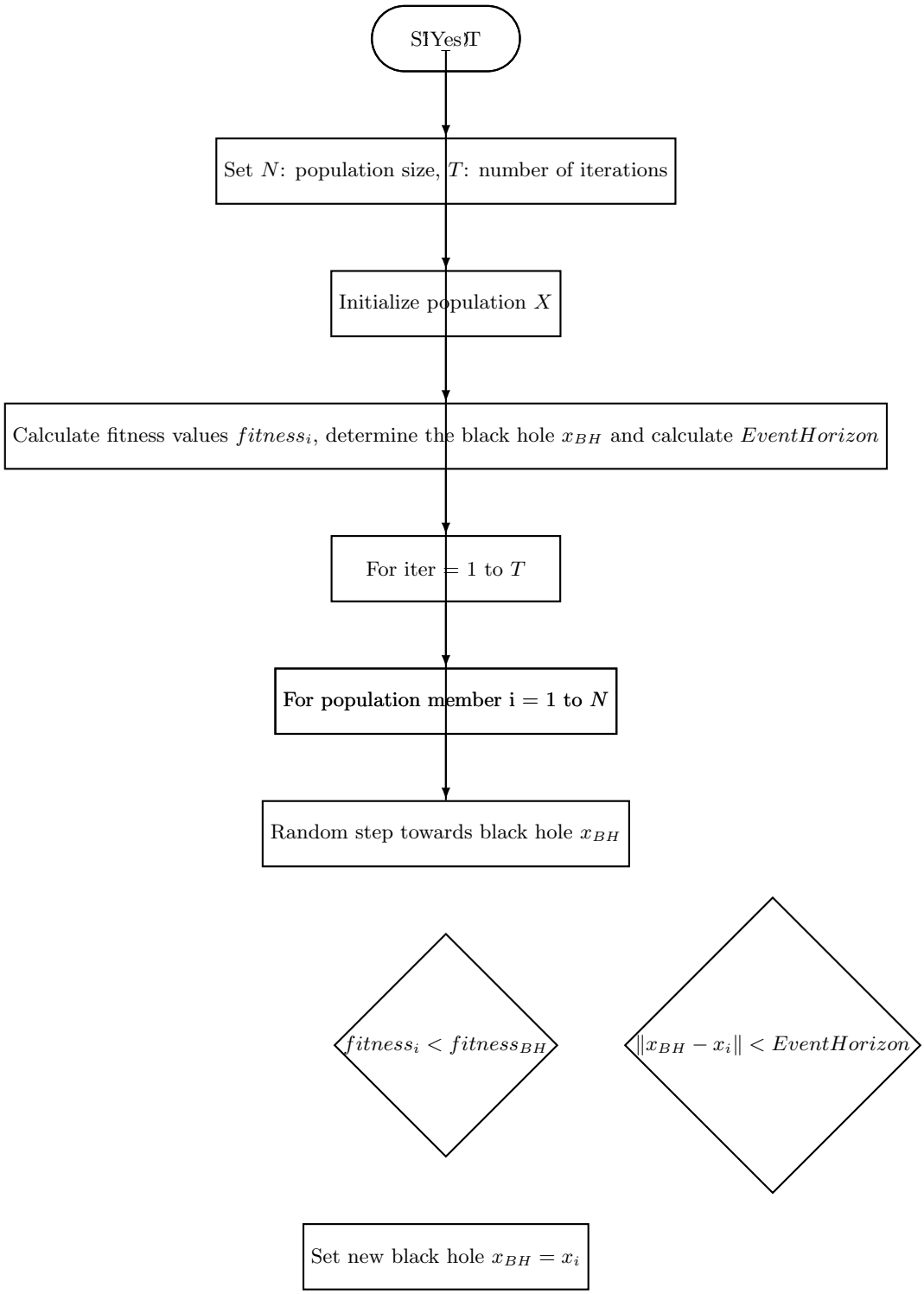

Figure 10.1: Flowchart of Black Hole Algorithm (BHA)

Bibliography

[1] Hatamlou, A., 2012. *Black hole: A new heuristic optimization approach for data clustering.* Information sciences, 2012: p. 175-184.

[2] M. Farahmandian, A. Hatamlou, 2015. *Solving optimization problems using black hole algorithm* Journal of Advanced Computer Science & Technology, 2015: p. 68-74.
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