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A modified firefly algorithm for global minimum optimization

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ABSTRACT

The Firefly algorithm is a population-based optimization algorithm. It has become popular in the field of optimization and has been applied to engineering practices. Recent works have failed to address how to find the global minimum because their algorithm was trapped in the local minimum. Also, they were not able to provide a balance between exploration and exploitation. In this paper, the Tidal Force formula has been applied to modify the Firefly algorithm, which describes the effect of a massive body that gravitationally affects another massive body. The proposed algorithm brings a new strategy into the optimization field. It is applied by using exploitation (Tidal Force) and keeping a balance between the exploration and exploitation on function suitability. Plate shaped, Steep Ridges, Unimodal and Multimodal benchmark functions were used to compare experimental results. The study findings indicate that the Tidal Force Firefly algorithm outperforms the other existing modified Firefly algorithms.

1. Introduction

Population-based optimization techniques have become widespread in the last two decades. Optimization problems are examined in a variety of fields, which consist of highly nonlinear, multimodal, multidimensional, and differentiable functions. However, traditional optimization techniques have not been able to solve these problems. The population-based techniques, with their own robustness and flexible behavior in solving optimization problems, bring novel insights in order to solve the problems instead of using traditional optimization techniques. The PSO algorithm is inspired by birds' behavior [1], which defines that all birds move towards the best bird. The PSO works with two populations, such as best position and current positions. Diversity solutions are one of the advantages of the PSO, which performs better than the single point algorithms. An ant colony is another popular algorithm that was designed for optimization problems. The algorithm is based on the behavior of ants and was proposed by Dorigo. Ants search for a best path solution between their colony and a food source. Each ant randomly moves towards a destination ant. The paths are followed by ants, based on the probability of pheromones [2]. Differential evolution based on individual's differences (called the DE algorithm) is similar to the GA algorithm that defines specified crossover, mutation and selection [3]. It computes parallels and takes the best result in a few dimensions. The Harmony Search (HS) algorithm was modeled by taking inspiration from the improvisation of musicians [4]. The algorithm uses musical Pitch Range, Harmony, Aesthetics, Practice and experience in the algorithm, which links to decision variables, iteration concepts and so on. The harmony (solution) is produced randomly and checks with stored solutions to place better solutions in their place. Biogeography-Based Optimization (BBO) was proposed using the concept of species immigration and emigration. Each species is moved to another place that is based on its own decision to take a feature of each other. One of the main advantages of this method is a critical distinction in the strategy that aids optimal performance in optimizing problems [5]. Gravitational Search Algorithm (GSA), based on Newtonian gravity and laws of motion, was also proposed. Bodies or mass may connect and move to each other based on the mentioned rule [6]. In order to improve the GSA, a new operator was proposed by [7] using black holes. The new operator is employed to avoid premature convergence phenomena and also balances exploration and exploitation. In their work, a star is stated as a black hole. One of the characteristics of black holes is Tidal Force, which uses a strong force (Tidal Force) to slice an object into smaller parts [7].

Swarm Intelligence is a family of population-based optimization techniques. Swarm Intelligence (SI), which is a branch of artificial intelligence (AI), is referred to as the design of intelligent multi agent systems. Multi-agent systems are inspired by the behavior of animal societies such as Ants, Termites, Bees, and Wasps, flocks of birds, schools of fishes [8], e.g., ABC [9], Ant and PSO. Some algorithms are categorized with a different class such as Swarm intelligence, Bio inspired, Physics chemistry-based algorithm and

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Firefly algorithm

Objective function f(x), x=$(x_1, \ldots, x_d)^T$
Generate initial population of fireflies $x_i (i = 1,2, \ldots, n)$
Light intensity I_i at x_i is determined by f(x_i)
Define light absorption coefficient γ
While (t<MaxGeneration)
  For i=1:n all n fireflies
    For j=1:n all n fireflies(inner loop)
      If ($I_i < I_j$), Move firefly i towards j; end if
      Vary attractiveness with distance r via exp(-γr)
      Evaluate new solutions and update light intensity
    end for j
  end for i
Rank the firefly and find the current global best g_*
End While
Postprocess results and visualization

Fig. 1. Pseudo code of firefly1 [18].

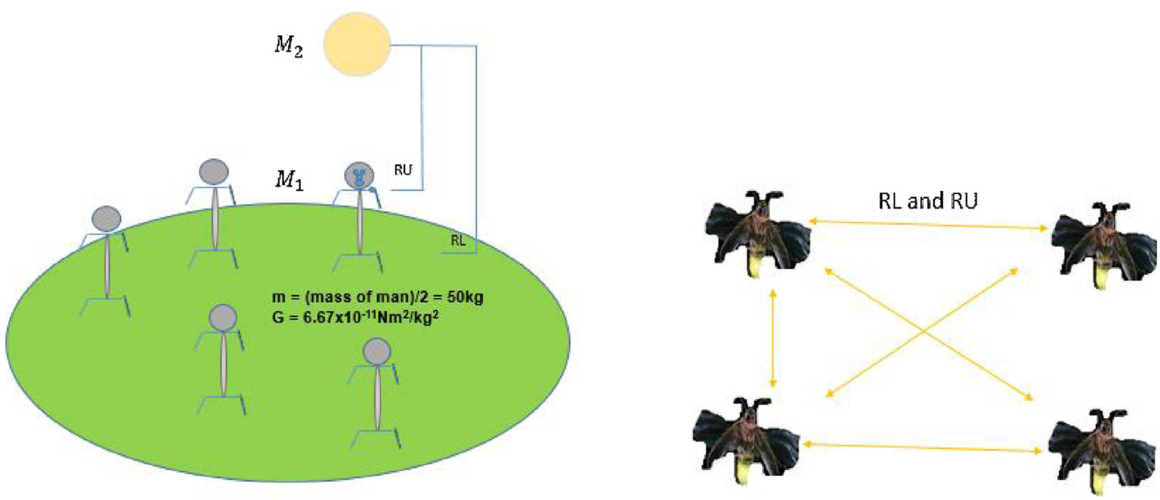

Fig. 2. Tidal Force.

Firefly Tidal algorithm

Objective function f(x), x=$(x_1, \ldots, x_d)^T$
Generate initial population of fireflies $x_i (i = 1,2, \ldots, n)$
Calculate opposite of population in fireflies $\tilde{x}_i$ (see 15,16)
Evaluate the fitness of both population $\tilde{x}_i and x$
Select the one of $\tilde{x}_i$ *and* x based on fitness function
Define G,m_1,m_2,alpha, MaxGeneration, nVar, β
Tidal Force I_i at x_i is
Define light absorption coefficient γ
  While (t<MaxGeneration)
    For i=1:n all n fireflies
      For j=1:n all n fireflies(inner loop)
        If ($I_i \neq I_j$)
        If ($I_i < I_j$), Move firefly i towards j; end if
        For k=1:nVar all n fireflies(inner loop) (variables mapped to vector in more dimensions)
        Vary attractiveness with distance r (see the formula 7,8,9,10,11,12)
        Evaluate new solutions and update Tidal Force (see the formula 13,14 or 15)
        End for k
        end if
      end for j
    end for i
Rank the firefly and find the current global best g_*
End While
Postprocess results and visualization

Fig. 3. Pseudo code of Tidal Force.