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Opposition and dimensional based modified firefly algorithm

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ABSTRACT

This paper presents the modified Firefly Algorithm (FA) originally proposed by Yang.

Firefly Algorithm is based on the idealized behavior of the flashing characteristics of the fireflies. Though firefly is powerful in local search, it does not search well globally due to being trapped in local optimum. Due to this reason, the convergence is generally slow. The FA also doesn't give efficient solution in high dimensional problems. The proposed approach gives more efficient solution with reduced time complexity in comparison to original FA. Two modifications made are: (1) Opposition-based methodology is deployed where initialization of candidate solutions is done using opposition based learning to improve convergence rate of original FA, which includes initializing the opposite number of positions of each firefly. This also ensures efficient searching of the whole search space, (2) The dimensional-based approach is employed in which the position of each firefly is updated along different dimensions. This results in more optimal solution. This algorithm works for High Dimensionality problems, especially in terms of accuracy in finding the best optimal solution and in terms of fast convergence speed as well. Several complex multidimensional standard functions are employed for experimental verification. Experimental results include comparison with other Evolutionary algorithms which show that the Opposition and Dimensional based FA (ODFA) gives more accurate optimal solution with high convergence speed than the original FA and those achieved by existing methods.

1. Introduction

Optimization is the process of selecting the optimum solution from the set of alternative ones. We have to either maximize or minimize the objective function by calculating the value of function using several input values from the given range of values. Evolutionary algorithms are being widely used in optimization problems. Reproduction, mutation, crossover, recombination, etc., mechanisms are used in such algorithms. Population is formed by the candidate solutions of the given problem and in every generation evolution of the population takes place by applying above mentioned mechanisms. In this paper, for optimization process, FA is used which is a simple, effective and robust global optimization algorithm with few control parameters. FA outperforms many other optimization methods like GA, PSO etc. Yang had done several researches on FA like FA has been applied to solve nonlinear design problems (Yang, 2010a), the search strategy of FA has been combined with Levy flights to improve its efficiency (Yang, 2010b), and FA has also been extended to solve multi objective problems (Yang, 2013). FA has been used is several applications which include structural optimization (Gandomi, Yang, & Alavi, 2011), cross entropy threshold selection (Horng & Liou, 2011), traveling salesman problem (Jati & Suyanto, 2011), clustering (Senthilnath, Omkar, & Mani, 2011), image compression (Horng, 2012) etc.

FA, being the global optimization method is originated from fireflies swarm. It finds the optimal solution by movements and updations (Wang, Guo, Wang, & Wang, 2013). However, this strategy is based on randomness, so we might not always get the global optima. Also, when FA is applied for higher dimensions, some dimensions give results close to global optima and some dimensions give results away from global optima (Yang & He, 2013). On the other hand, we add a mutation to the fireflies, which includes opposition and Dimension based learning, which includes finding solutions in the opposite direction and multiple dimension. This increases the search space of finding the global optima (Ergezer, 2011; Wang, Li, Chen, & Qin, 2013).

The approach of opposition-based learning (OBL) was given by Tizhoosh (Tizhoosh, 2005a). Here, whole search space is searched efficiently by considering the corresponding opposite estimate simultaneously along with the estimate. So, the current estimate is searched in two directions and the search space is searched more efficiently. The opposition based optimization helps the solution to converge faster hence reduces the time complexity. The comparison between randomness and opposition based approach has been

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Begin

Let Fitness function be $f(x)$ *where* $x = (x_1, x_2, ..., x_D)$

Generate an initial population of fireflies x_i $(i = 1, 2, ... n)$

Light intensity I_i *at* x_i *is determined by* $f(x_i)$

Define the light absorption coefficient γ

While *(t <MaxGeneration)*

For $i = 1$ to n *all n fireflies*

For $j = 1$ to n *all n fireflies*

If *(*$I_j > I_i$*)*

Move firefly i *towards* j *in d-dimension*

End if

Attractiveness varies with distance r via $\beta_0 e^{-\gamma r^2}$

Evaluate new solutions and update light intensity

End for j

End for i

Rank the fireflies and find the current best

End while

Post process results and visualization

End

Fig. 1. Pseudo code of Firefly Algorithm.

done in Tizhoosh, Rahnamayan, and Salama, 2008, which proves that opposition based learning gives better results in less time. OBL has been applied in image segmentation (Tizhoosh & Sahba, 2007), management of water resources (Tizhoosh, Ponnambalam, & Mahootchi, 2007), learning in neural network (Tizhoosh, 2005b) etc. In this paper, OBL has been used at the time of population initialization. This gives the better approximation of the initial values of the particles and hence the solution converges faster.

There are situations, particularly for high dimensional data points, when one or fewer dimensions force a data point to be away from a given cluster. The odd parametric values of fewer dimensions, although apparently looks absurd, but in practice is apparent in real-world measurements. This paper proposes a solution to the above problem, by giving importance to each dimension to independently participate in global solution.

The major contribution of this paper in the field of Evolutionary Algorithms compared to other approaches would be a significantly less time complexity. Firefly algorithm has two inner loops when going through the population n, and one outer loop for number of generations G. So the complexity at the worst case is order of $n^2 * G$(represented as $O(n^2 * G)$). The time complexity is very high. The same applies to many other Evolutionary Algorithms (BFO, PSO, ACO etc.). But in modified firefly algorithm, for each iteration, we need to find the Gbest (global best firefly) whose complexity is $O(n*D)$ where D is the number of dimensions and then update each of the firefly using that Gbest firefly only, whose complexity is O(n), we do not need the comparison of each firefly with all other fireflies. Therefore the time complexity becomes $(O(G(n * D + n))) = O(G(n * D))$. Hence, the time complexity of modified algorithm is much lesser than original FA.

The rest paper is arranged in the following manner: Section 2 gives the overview of the Firefly algorithm. Section 3 reviews the OBL. Section 4 describes the proposed method. Section 5 shows the experimental results obtained through proposed algorithm and conclusions are given in section 6.

2. Firefly algorithm

This section reviews Firefly algorithm proposed by Yang in 2008 (Yang, 2008). FA consists of three idealized rules: (1) Regardless of its sex, each firefly will be attracted towards every other fireflies i.e. they are considered unisexual, (2) Attraction of one firefly towards another