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Female Percentage in Firefly Algorithm

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1 INTRODUCTION

Swarm intelligence is receiving a lot of attention in various fields. One of swarm intelligence algorithms is Firefly Algorithm (FA). The conventional FA is composed of one swarm. In nature, it is important to have a diversity in order to fit various environments. Therefore, we distinguish sex of fireflies so that algorithm has diversity. This proposed algorithm is called Firefly Algorithm Distinguishing between Males and Females. In this study, we focus on effect of female percentage.

2 FIREFLY ALGORITHM (FA)

On FA, fireflies search optimal solution according to each attractiveness. Attractiveness is proportional to the their brightness. The less brighter(darker) firefly move towards the brighter one. The brightness of a firefly is affected by the landscape of the objective function and decrease as distance increases.

Attractiveness of firefly β is defined by

$$\beta = \beta_0 e^{-\gamma r_{ij}^2} \tag{1}$$

where γ is the light absorption coefficient, β_0 is the attractiveness at $r_{ij} = 0$, and r_{ij} is the distance between any two fireflies i and j at $\boldsymbol{x_i}$ and $\boldsymbol{x_j}$. The movement of the firefly i is attracted to another more attractive firefly j, and is determined by

$$\boldsymbol{x_i} = \boldsymbol{x_i} + \Delta\boldsymbol{x}, \tag{2}$$

$$\Delta\boldsymbol{x} = \beta(\boldsymbol{x_j} - \boldsymbol{x_i}) + \alpha\boldsymbol{\epsilon_i}, \tag{3}$$

where $\boldsymbol{x_i}$ is the position vector of firefly i, $\boldsymbol{\epsilon_i}$ is the vector of random variable, and $\alpha(t)$ is the randomization parameter. The parameter $\alpha(t)$ is defined by

$$\alpha(t) = \alpha(0)\left(\frac{10^{-4}}{0.9}\right)^{t/t_{max}}, \tag{4}$$

where t is the number of iteration.

3 PROPOSED METHOD

In nature, it is important to have a diversity in order to survive and fit various environments. Therefore, we distinguish sex of fireflies, that is, there are two kinds fireflies in our proposed method. We call our proposed method Firefly Algorithm Distinguishing between Males and Females (FADMF). In our proposed method, moving distance of females is shorter than males, and females have difficulty finding the flashes of other distant fireflies. In addition, we change the randomization parameter of female.

The female parameters $\alpha(t)$ and β, and the female movement $\boldsymbol{x}$ is determined with parameters V and W by

$$\alpha(t) = \alpha(0)\left(\frac{10^{4}}{0.9}\right)^{t/2t_{max}}, \tag{5}$$

$$\beta = \beta_0 e^{-\gamma r_{ij}^2/W}, \tag{6}$$

$$\boldsymbol{x} = \boldsymbol{x} + \Delta\boldsymbol{x}/V. \tag{7}$$

In the proposed method, males are attracted to all fireflies, while females are attracted to only males. Males move the same as fireflies of the conventional FA.

4 NUMERICAL EXPERIMENT

We compare FADMF to the conventional FA with 8 composition functions of CEC 2013 benchmark functions. Table1 shows how many times the proposed FA wins the conventional FA in the comparison for the 8 composition functions. The dimension N is 30, the search range of these functions is $[-100, 100]^N$, the maximum number of iteration is 1500, and each numerical experiment is run 50 times.

Table 1 Numerical Experiments

Female Percentage	10	20	30	40	50	60	70	80	90
Num. of Function	4	4	5	5	6	6	3	2	2

Table1 indicates female percentage is suitable for 50 or 60. As female percentage increases until 50, the number of function increases, and then the number of function immediately decreases. Females tend to converge slowly because the moving distance of females is shorter than males. We assume that FADMF is more hardly falling into local optima as female percentage increases. However, FADMF becomes local search algorithm when female percentage is too large.

5 CONCLUSION

We have proposed improved Firefly Algorithm that distinguishes sex of fireflies. In this study, we focus on female percentage of our proposed method. We assume that FADMF is more hardly falling into local optima when female percentage is suitable value.