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Firefly Algorithm Distinguishing between Males and Females

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1. Introduction

The swarm intelligence algorithm is based on behavior of animals and insects. Representative examples are Particle Swarm Optimization (PSO), Ant Colony Optimization (ACO) and Firefly Algorithm (FA) [1–2]. All fireflies are defined as unisex on FA. Therefore, we distinguish sex of firefly. The proposed method is called Firefly Algorithm Distinguishing between Males and Females (FA-DMF). In this study, we compare FA-DMF to FA with famous three test functions.

2. Firefly Algorithm (FA)

FA is based on the idealized behavior of the flashing characteristics of firefly. It is suitable for multi-peak optimization problems. Attractiveness is proportional to their brightness, and attractiveness and brightness both decrease as their distance increases. The brightness of firefly is affected by the landscape of the objective function to be optimized. For any two flashing fireflies, the less brighter one moves toward the brighter one. The brightest firefly moves randomly. Thus, they search the optimal solution. 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, ϵ_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. FA-DMF

In our proposed method, there are two swarms. The two swarms represent male and female. We define that half fireflies are males and the rest are females. The movement of female is modeled from the characteristics of the real firefly. In the real world, females are bigger than males and female eyes are smaller than male. Therefore, in our proposed method, females move slower 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 this study, males are attracted to all of firefly, while females are attracted to only males. In addition, males move the same as fireflies of FA.

4. Numerical Experiments

We compare FA-DMF to FA with three test functions (see Table 1). These optimal solutions are $f(x) = 0$ at $x = 0$.

Table 1: The Test Functions

name	Formula	Range
Sphere	$f(x) = \sum_{i=1}^{n} x_i^2$	[-5.12,5.12]
Rastrigin	$f(x) = \sum_{i=1}^{n} (x_i^2 - 10\cos(2\pi x_i) + 10)$	[-5.12,5.12]
Griewank	$f(x) = \frac{1}{4000}\sum_{i=1}^{n} x_i^2 - \prod_{i=1}^{n} \cos(\frac{x_i}{\sqrt{i}}) + 1$	[-600,600]

Each numerical experiment is run 100 times. In each test function, we define the number of fireflies $n = 30$, the number of dimensions $N = 30$, $t_{max} = 900$, $W = 2$ and $V = 3$. Numerical experiment results are shown in Table 2.

Table 2: Numerical Experiment Results

name		FA	FA-DMF
Sphere	ave	2.81×10^{-7}	$\mathbf{1.27 \times 10^{-7}}$
	min	1.67×10^{-7}	$\mathbf{6.66 \times 10^{-8}}$
	max	3.75×10^{-7}	$\mathbf{1.94 \times 10^{-7}}$
Rastrigin	ave	2.66×10^{1}	$\mathbf{1.53 \times 10^{1}}$
	min	1.49×10^{1}	$\mathbf{4.97 \times 10^{0}}$
	max	4.97×10^{1}	$\mathbf{3.38 \times 10^{1}}$
Griewank	ave	$\mathbf{2.07 \times 10^{-4}}$	2.26×10^{-4}
	min	1.31×10^{-4}	$\mathbf{1.24 \times 10^{-4}}$
	max	$\mathbf{2.85 \times 10^{-4}}$	1.72×10^{-2}

In Sphere and Rastrigin functions, FA-DMF obtains better results. In Griewank function, FA-DMF also obtains better result about min, while FA-DMF obtains worse results about ave and max.

5. Conclusions

In this study, we have proposed a new firefly algorithm, and have compared to the conventional firefly algorithm. Our numerical experiment results show that FA-DMF is superior to FA in Sphere and Rastrigin functions. In the future works, we improve FA-DMF, and apply multi-peak optimization problems.

References

[1] Yang, X.S., “Nature-Inspired Metaheuristic Algorithms Second Edition”, Luniver Press, 2010.

[2] Yang, X.S., “Firefly Algorithm, Stochastic Test Functions and Design Optimization”, Int. J. Bio-Inspired Computation, vol.2, pp.78-84, 2010.