1-36

Firefly Algorithm with Bernoulli Shift Map

Masaki MORIYAMA , Masaki TAKEUCHI , Yoko UWATE and Yoshifumi NISHIO
(Tokushima University)

1. Introduction

Recently, nature-inspired metaheuristic optimization algorithms such as Firefly Algorithm(FA) has been developed. FA idealizes the social behavior of fireflies based on their flashing characteristics. Furthermore, FA combined with chaotic map is to be of benefit.

In this study, we propose an algorithm that is combined FA with Bernoulli shift map. Compared to the previous study, we investigate a difference approach to insert chaotic map into the conventional FA.

2. Conventional Firefly Algorithm

The conventional FA was developed by Xin-She Yang in 2007. We use the following three idealized rules:

- All fireflies are unisex so that one firefly will be attracted to other fireflies regardless of their sex.
- Attractiveness is proportional to the their brightness, thus for any two flashing fireflies, the less brighter one will move towards the brighter one. The attractiveness is proportional to the brightness and they both decrease as their distance increases. If there is no brighter one than a particular firefly, it will move randomly.
- The brightness of a firefly is affected or determined by the landscape of the objective function.

The 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 located at x_i and x_j respectively. The firefly i is attracted to another more attractive firefly j, and the movement of firefly i is determined by

$$\boldsymbol{x_i} = \boldsymbol{x_i} + \beta(\boldsymbol{x_j} - \boldsymbol{x_i}) + \alpha \boldsymbol{\epsilon_i} \tag{2}$$

where α is the randomization parameter, and ϵ_i is a random vector which are drawn from a Gaussian distribution.

The parameter $\alpha(t)$ is defined by

$$\alpha(t) = \alpha(0) \left(\frac{10^{-4}}{0.9} \right)^{t/t_{max}} \tag{3}$$

where t is the number of iteration.

3. Proposed method

We propose the improved FA(IFA). IFA is combined the conventional FA with Bernoulli shift map. Bernoulli shift map is one of the one-dimensional chaotic maps, which is the simplest systems with the capability of generating chaotic motion. It generates chaotic sequences in (0, 1) assuming Eq. (5). In the previous study, the attractiveness of firefly and the light absorption coefficient are tuned with chaotic map. In IFA, we insert Bernoulli shift map into the vector of random variable.

$$\boldsymbol{x_i} = \boldsymbol{x_i} + \beta(\boldsymbol{x_j} - \boldsymbol{x_i}) + \alpha(\boldsymbol{\epsilon_i} + \boldsymbol{z_i}) \tag{4}$$

The Bernoulli shift map belongs to the class of piecewise linear maps similar to the logistic map or the Kent map. It is formulated as follows:

$$z_{i+1} = \begin{cases} 2z_i & (0 \le z_i \le 0.5) \\ 2z_i - 1 & (0.5 \le z_i \le 1). \end{cases} \tag{5}$$

4. Numerical experiment

We compare IFA to the conventional FA by using 5 benchmark functions of Congress on Evolutionary Computation 2013. In this experiment, the optimal solutions x^* of these benchmark functions is shifted from 0, and the global optima $f(x^*)$ are not equal to 0. In addition, we assign the search range of these function is $[-100, 100]^D$ (D:Dimention), the number of firefly N is 30. Each numerical experiment is run 50 times. Furthermore, we use β_0 is 1.0 and γ is 1.0. In this sumilation, we compare the average of sumilation results. In results, IFA performs better on 3 functions.

Table 1: 2013 CEC Benchmark Functions

No.	Name	$f(x^*)$
1	Sphere Function	-1400
2	Rotated Rosenbrock's Function	-900
3	Rotated Griewank's Function	-500
4	Composition Function 2 (n=3,Unrotated)	800
5	Composition Function 5 (n=3,Rotated)	1100

Table 2: Simulation results

f		FA	IFA
f_1	avg	6.45×10^{-4}	$\mathbf{6.26 \times 10^{-4}}$
	min	4.32×10^{-4}	3.27×10^{-4}
	max	9.66×10^{-4}	1.07×10^{-3}
f_2	avg	2.73×10^{1}	$\mathbf{2.72 \times 10^{1}}$
	min	2.54×10^{1}	2.53×10^{1}
	max	2.85×10^{1}	2.83×10^{1}
f_3	avg	5.63×10^{-1}	$\mathbf{4.06 \times 10^{-1}}$
	min	4.15×10^{-2}	7.28×10^{-2}
	max	2.23×10^{0}	1.70×10^{0}
f_4	avg	$\mathbf{3.31 \times 10^{3}}$	3.46×10^{3}
	min	6.08×10^{2}	1.36×10^{3}
	max	6.27×10^{3}	6.13×10^{3}
f_5	avg	2.33×10^{2}	2.33×10^{2}
	min	2.01×10^{2}	2.19×10^{2}
	max	2.53×10^{2}	2.50×10^{2}

5. Conclusion

This paper introduced the improved Firefly Algorithm(IFA). We tried to improve the conventional FA using Bernoulli shift map. IFA performed better than the conventional FA.

In the future work, we will investigate Firefly Algorithm by using more functions and insert other chaotic maps.