Research of Firefly Algorithm Combined with Chaotic Map

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I. Introduction

Recently, nature-inspired metaheuristic optimization algorithms such as Firefly Algorithm (FA) have been developed. In a previous study, FA combined with chaotic map was confirmed to be of benefit.

In this study, we investigate an FA algorithms which is combined FA with a one-dimensional chaotic map. Compared to the previous study, we investigate a different approach to insert chaotic map.

II. Firefly Algorithm (FA)

FA is idealized from some of the flashing characteristics of fireflies [1].

The attractiveness of firefly β is defined by

$$\beta = (\beta_0 - \beta_{min})\mathrm{e}^{-\gamma r_{ij}^2} + \beta_{min} \quad (1)$$

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 $\boldsymbol{x}_i$ and $\boldsymbol{x}_j$. β_{min} is the minimum value of β. The firefly i is attracted to another more attractive firefly j and the movement of firefly i is determined by

$$\boldsymbol{x}_i = \boldsymbol{x}_i + \beta(\boldsymbol{x}_j - \boldsymbol{x}_i) + \alpha\boldsymbol{\epsilon}_i \quad (2)$$

where α is the randomization parameter and $\boldsymbol{\epsilon}_i$ is a random vector which is drawn from a Gaussian distribution.

III. Our proposed method

We introduce the improved FA (BFA, TFA and LFA). BFA, TFA and LFA are combined FA with Bernoulli shift map, Tent map and Logistic map, respectively. These maps are one of the one-dimensional chaotic maps, which is the simplest systems generating chaotic motion. In the previous study, A.H. Gandomi et al inserted chaotic maps into the attractiveness of firefly β and the light absorption coefficient γ [2]. In this study, we insert a chaotic map into the vector of random variable.

$$\boldsymbol{x}_i = \boldsymbol{x}_i + \beta(\boldsymbol{x}_j - \boldsymbol{x}_i) + \alpha(\boldsymbol{\epsilon}_i + \boldsymbol{z}_i) \quad (3)$$

where $\boldsymbol{z}_i$ is one-dimensional chaotic map.

IV. Numerical simulation

We compare BFA, TFA and LFA with the conventional FA using 7 benchmark functions of Congress on Evolutionary Computation (CEC) 2013. Table I shows the functions we used. We chose 2 unimodal functions, 3 basic multimodal functions and 2 composition functions.

In this simulation, the optimal solutions x^* of these benchmark functions are 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: Dimension), the number of firefly N is 30. Each numerical experiment is run 50 times. The average length of design variables L is 100. Furthermore, we use $\beta_0 = 1.0$, $\beta_{min} = 0.2$, $\gamma = \frac{1}{\sqrt{L}}$, $D = 30$ and $t_{max} = 1500$.

Table II shows the average error values.

TABLE I
2013 CEC benchmark functions

No.	Name	$f(x^*)$
f_1	Sphere Function	-1400
f_2	Rotated Discus Function	-1100
f_3	Rotated Rosenbrock's Function	-900
f_4	Rotated Weierstrass Function	-600
f_5	Rotated Griewank's Function	-500
f_6	Composition Function 2 (n=3, Unrotated)	800
f_7	Composition Function 5 (n=3, Rotated)	1100

TABLE II
Simulation results

f	FA	BFA	TFA	LFA
f_1	6.45×10^{-4}	6.26×10^{-4}	$\mathbf{6.11 \times 10^{-4}}$	6.45×10^{-4}
f_2	1.22×10^5	1.19×10^5	$\mathbf{1.14 \times 10^5}$	1.20×10^5
f_3	2.73×10^1	$\mathbf{2.72 \times 10^1}$	2.73×10^1	2.73×10^1
f_4	1.04×10^1	9.86×10^0	1.03×10^1	$\mathbf{9.70 \times 10^0}$
f_5	5.63×10^{-1}	$\mathbf{4.06 \times 10^{-1}}$	5.39×10^{-1}	5.15×10^{-1}
f_6	3.31×10^3	3.46×10^3	$\mathbf{3.11 \times 10^3}$	3.26×10^3
f_7	$\mathbf{2.33 \times 10^2}$	$\mathbf{2.33 \times 10^2}$	2.34×10^2	$\mathbf{2.33 \times 10^2}$

In this simulation, we compare the average error values of BFA, TFA and LFA. BFA performs best for 2 functions (f_3 and f_5). TFA performs best for 3 functions (f_1, f_2 and f_6). LFA performs best for a function (f_4). In f_7, improved FA does not perform better than FA. Hence, TFA is the best algorithm among our proposed three algorithms.

V. Conclusion

This study introduced the improved Firefly Algorithm (BFA, TFA and LFA). We compared average error values of simulation results. TFA is the best algorithm among our proposed three algorithms.

References

[1] X.-S. Yang, *"Nature-Inspired Metaheuristic Algorithms Second Edition"*, Luniver Press (2010).

[2] A.H. Gandomi, X.-S. Yang, S. Talatahari and A.H. Alavi, *"Firefly Algorithm with Chaos"*, Commun Nonlinear Sci Numer Simulat, 18, pp.89-98 (2013).