Research on Optimization and Application of Firefly Algorithm Based on Cloudsim

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Keywords: Firefly algorithm, Fluorescein value, Local optimum, Cloudsim.

Abstract. Aiming at the phenomenon that firefly algorithm has premature convergence and easy to fall into local optimum, an optimized firefly algorithm is proposed by improving the range of the fluorescein value on the basis of firefly algorithm and greedy strategy in this paper. Through the Cloudsim simulation platform, it is found that the improved algorithm has a significant improvement in the search progress and performance, and can effectively prevent these defects that the convergence is too fast and the objective function value is easy to fall into the local optimum. Finally, the algorithm is applied to the optimization problem of the objective function, and the simulation results show that the improved algorithm has a certain degree of effectiveness.

Introduction

In 2007, Yang, a British scholar in Cambridge, proposed a firefly algorithm, which is a new intelligent optimization method, and the luminous properties of fireflies are a biological feature. Firefly algorithm is a process, which is based on the brightness of the firefly itself and the attraction of other fireflies to describe its location. The position of fireflies and their attraction are closely related to their brightness. According to relevant scholars, the brighter the firefly, the more obviously it moves. The moving of Firefly is according to the position of other fireflies, which is also the process of firefly's position moving in firefly algorithm.

Firefly algorithm has aroused heated discussions both at home and abroad since it was put forward. However, firefly algorithm itself has some limitations, especially after its operation for a certain period of time, it is easy to fall into the defects of slow convergence speed. Therefore, the idea proposed in this paper has optimized the algorithm, and the optimized algorithm has great application value in various fields.

Firefly Algorithm

The Principle of Firefly Algorithm

Suppose that the number of fireflies is m, and the dimension of the search space is N, then the initial coordinate position of the firefly i in N dimension space can be expressed as

\[ x_i = (x_{i1}, x_{i2}, x_{i3}, \cdots, x_{in}) \]

Definition 1. The initial brightness of fireflies.

\[ I_0 = f(x_i) \] (1)

\( f(x_i) \) is the fitness of the firefly i according to the objective function.

Definition 2. Relative fluorescence brightness of fireflies.

\[ I(r) = I_0 e^{-r \gamma} \] (2)
Definition 3. The attraction of fireflies

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

Define a new location for firefly i to move after being attracted by the firefly j.

$$
x_i(t+1) = x_i(t) + \beta (x_j(t) - x_i(t)) + \alpha \text{rand} - 1/2
$$

Through the above formula, we can see that the firefly algorithm is a simple algorithm, it is applied in various fields of very important aspects. The performance of the algorithm is only affected by the individual parameters, which is mainly reflected in the following aspects:

1. Population size
   It refers to the number of fireflies, and it is the most important parameter that affects the performance of firefly algorithms.

2. Absorption factor of light intensity
   $$
   \beta = \beta_0 e^{-\gamma r_{ij}}
   $$
   If $$r \to 0$$, then $$\beta \to \beta_0$$, the formula used to update the position will become:

   $$
   x_i(t+1) = x_i(t) + \beta_0 (x_j(t) - x_i(t)) + \alpha \text{rand} - 1/2
   $$
   If $$\beta_0$$, then

   $$
   x_i(t+1) = x_j(t) + \alpha \text{rand} - 1/2
   $$
   If $$r \to \infty$$, then $$\beta \to 0$$, the formula used to update the position will become:

   $$
   x_i(t+1) = x_i(t) + \alpha \text{rand} - 1/2
   $$

3. The main purpose of introducing $$\alpha$$ into the formula is to improve the size of the population in the firefly algorithm, so as to expand the search ability of firefly and prevent the convergence too low.

Analysis of the Characteristics of Firefly Algorithm

According to the above description of firefly algorithm, we can get the following characteristics of firefly algorithm:

1. Firefly algorithm is a population size algorithm based on the simulation of the biological characteristics of fireflies. It has obvious effect in the application of various fields.

2. The activity of firefly individuals with fluorescence activity reflects the ability of firefly individuals to work together. Fireflies move in the process of moving toward the optimum and the highest fluorescence position.

3. The robustness of the algorithm is strong. Because fireflies move randomly, they do not have specific reference in the process of moving, and lack of optimization experience. Therefore, each individual must have strong robustness and adaptability.

Optimization of Firefly Algorithm Based on CloudSim

A Brief Introduction to a Cloud Computing Simulation System Called CloudSim

The software named CloudSim was successfully launched in 2009 by the experimental project at Melbourne University in Australia. It can imitate real cloud computing system and application environment, and it is a dynamic software package used for modeling and simulation. Cloud Sim is
open source, can run on windows, Linux and other operating systems, is a very convenient and easy to
expand scientific research software.
In this paper, CloudSim platform is used to simulate the improved firefly algorithm, and the
effectiveness of the algorithm is analyzed through simulation results.

The Idea of Optimizing Firefly Algorithm

In this paper, an improved method for formula \( J(t + 1) = (1 - \rho)J(t) + \gamma f(x, t + 1) \) of calculating the
fluorescein value is put forward, and its value is defined between [lmin, Lmax], such as formula 2.1.

\[
J_i(t) = J_i(t - 1) + e^{\frac{j_{min}}{j_{max}}} \gamma f(x_i(t))
\]

The improved algorithm can better avoid the local convergence of the fluorescein value, so it improves
the performance of finding the optimal solution, and accords with the rule of using task resources.

Steps of Algorithm

(1) Set the values of the firefly algorithm to the minimum lmin and the maximum lmax.
(2) Calculate the fluorescein value of each firefly individual.
(3) Control the value of fluorescein.
(4) Select the best firefly.
(5) Recalculate the moving direction of fireflies.
(6) Judge the condition. If the condition is satisfied, output the optimal solution directly.

Simulation Experiment

First, the effectiveness of the algorithm is analyzed by three basic functions, and then the algorithm
is tested with CloudSim simulation software. The three functions are the Sphere function, the
Goldstein-Price function and the Goldstein-Price function.

(1) Sphere function

\[
f(x) = \sum_{i=1}^{n} x_i^2 - 100 \leq x \leq 100
\]

(2) Goldstein-Price function

\[
f(x) = \left[ 1 + (x_1 + x_2 + 1)^2 \left( 9 \cdot 14 + 3 x_1 + 14 x_2 + 6 x_1 x_2 + 3 x_1^2 + 2 x_2^2 \right) \right]
\]

\[
+ (2 x_1 - 3 x_2)^2 \left[ 98 - 32 x_1 + 12 x_1 x_2 + 12 x_2 + 27 x_2^2 \right]
\]

\[-2 \leq x_i \leq 2, \ i = \{1, 2\}
\]

(3) Ackley function

\[
f(x) = -20 \exp \left( -0.2 \sqrt{\frac{1}{n} \sum_{i=1}^{n} x_i^2} \right) - \exp \left( \frac{1}{n} \sum_{i=1}^{n} \cos 2\pi x_i \right) + 20 + e
\]

\[-32 \leq x_i \leq 32
\]

After the firefly algorithm is improved, the numerical value of the firefly algorithm needs to change
accordingly. First, the initial values need to be changed to 500. In addition, the number of iterations,
the fluorescein values need to be changed to 200, 0.5, and so on.

Table 1. Comparison of the results of test functions.

| Function       | Terms of contrast | Artificial firefly algorithm | The algorithm in this paper |
|----------------|-------------------|-----------------------------|-----------------------------|
| Sphere         | Optimal result    | 0.0212458                   | 0.0019541                   |
|                | Worst result      | 0.0298742                   | 0.0105412                   |
|                | Average value     | 0.0255600                   | 0.0062476                   |
| Goldstein-Price| Optimal result    | 3.0005124                   | 3.0000001                   |
|                | Worst result      | 3.0014521                   | 3.0000224                   |
|                | Average value     | 3.00009822                  | 3.0000112                   |
| Ackely         | Optimal result    | 3.4589122                   | 3.2456212                   |
|                | Worst result      | 3.6521471                   | 3.3562141                   |
|                | Average value     | 3.5555296                   | 3.309176                    |
It can be seen from table 1 that the improved firefly algorithm is obviously better than the improved algorithm, and also shows that the improvement is an effective improvement.

The Experiment of Simulation and the Analysis of the Result

Taking the task of 10 job scheduling as an example, the improved firefly algorithm completes the task time differently. Specific results are as follows:

- Table 1: Simulation results of scheduling with.
- Table 2: Simulation results of improved firefly algorithm sequential allocation strategy.

As shown in Figure 1 and Figure 2, the improved firefly algorithm is significantly better than the original firefly algorithm as the task size continues to expand.

In addition, the improved firefly algorithm and the standard firefly algorithm have different differences in the optimization time, as shown in Figure 3.

Application of Firefly Algorithm

Solving Clustering Problems

Clustering analysis is a commonly used data analysis method in data mining field. At present, scholars at home and abroad on the cluster analysis of the research has formed a relatively rich theoretical results. It makes the process of data processing more accurate. At present, there are many kinds of clustering algorithms, but they are easy to fall into local optimum. Therefore, these algorithms still have much room for improvement.
Simulation of Experiments and Analysis of the Results

(1) The simulation results of function optimization problem

In this paper, the four peak function \( f(x, y) \) is chosen as the objective function. Through this function to verify the performance of the algorithm, the global optimal solution and the local optimal solution are obtained.

\[
f(x, y) = e^{-|x-4|+|y-4|^2} + e^{-|x+4|+|y-4|^2} + 2\left(e^{-x^2-y^2} + e^{-x^2-(y+4)^2}\right)
\]

Based on the same experimental conditions, the optimization time and average optimal value of the GFA algorithm and the FA algorithm on the function \( f(x, y) \) are compared. The result of running 50 times is shown in Table 2.

| Algorithm | Times of iteration | Average searching time | The average of the maximum |
|-----------|--------------------|------------------------|---------------------------|
| GFA       | 16                 | 6.618751               | 2.0500                    |
| FA        | 24                 | 6.916001               | 2.0500                    |

(2) Simulation results on clustering problems

In the improved firefly algorithm, the population size \( N=20 \), step size factor \( \alpha = 0.2 \), maximum attraction degree \( \beta = 1 \), minimum attraction degree \( \beta_{min} = 0.2 \), medium absorption factor \( \gamma = 1 \), and maximum iteration number 100 are calculated. Table 3 lists the optimal values and the minimum values obtained after 20 experiments.

| Algorithm | Optimal value | Worst value | Average value |
|-----------|---------------|-------------|---------------|
| GFA       | 96.6554       | 1.0194e+02  | 1.0012e+02    |
| FA        | 98.7559       | 96.6557     | 96.6555       |

From the data of Table 3, it can be seen that the CFA algorithm is more valuable than the FA algorithm in clustering problem.

Concluding Remarks

In summary, the improved firefly algorithm is better than the standard firefly algorithm. The convergence of the algorithm and the problem of easily falling into the local optimum are optimized. Simulation results show that the performance and effectiveness of the algorithm are verified, and the complex function can be solved more accurately in the optimization of the function.

Acknowledgements

This research is sponsored by the Project of National Science and Technology Supporting Program for the Twelfth Five-years Plans(2014BAH25F03),and the software Engineering Discipline Construction Project of Beijing Information Science and Technology University(5121723402).

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