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Basic principle of cuckoo optimization algorithm

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Abstract: This paper introduces the basic principle of cuckoo algorithm from cuckoo's habits. The cuckoo algorithm can be applied to more data analysis and processing, providing a basic principle for cuckoo algorithm data processing, and laying a solid foundation for the improvement of cuckoo algorithm.

Keywords: Cuckoo algorithm; Improved algorithm; Processing of data.

1. Introduction

In nature, cuckoo, also known as cuckoo, mostly lives in the woods of tropical and temperate regions. It is famous for its distinctive call "cuckoo cuckoo". It is a very mysterious bird, which breeds its offspring and never nests. And the owner of the nest in the excess of other eggs to eat, let the nest owner to help it raise the next generation, really can be described as the nature of the "preger". Cuckoo chicks typically need less time to hatch than their host's eggs do to develop, and their innate ability is to kill other chicks and then mimic their calls to increase the chances that the nest host will provide them with food. Nick Vickers, a professor of ecology at the University of Cambridge, has studied the habits of cuckoos and kept records of their breeding habits.

2. Basic principles of Cuckoo optimization algorithm

2.1. The origin of the cuckoo algorithm

In 2009, scholars Xin-She Yang and Suash Deb created a new and more intelligent heuristic algorithm -- CS algorithm, which can be used to optimize parameters, based on the connection between cuckoo parasitic breeding behavior and optimization algorithm. Osman explains the heuristic algorithm as follows: On the basis of iterative random optimization, it constructs the algorithm logic according to the biological behavior in nature, guides the algorithm to explore the search space, uses the learning strategy to generate information, and obtains the optimal solution of the optimization parameters through the most effective path. The biggest feature of this kind of algorithm is that it draws on the natural law phenomenon or the principle of biomimetic, in which scholars design intelligent optimization algorithm according to the natural law

According to the researchers' paper, Lexy flight is a characteristic of most flying animals in nature, with a sharp 90-degree turn in a straight-line flight and a sudden, large step forward in a slow flight to change the trajectory of movement. Figure 1 describes the motion track of 800 steps of Levy flight iteration, in order to understand Levy flight characteristics more directly through the figure. Cuckoo belongs to one of the natural flying birds. The walking pattern and movement characteristics of cuckoo searching for nesting nests at random are consistent with Levy distribution. From the perspective of mathematical problems, Lexy flight is a typical random walk process. The distribution formula is as follows:

$$L(s,\gamma,\mu)=\begin{cases}\sqrt{\frac{\gamma}{2\pi}}\exp\left[-\frac{\gamma}{2[s-\mu]}\right]\frac{1}{(s-\mu)^{3/2}},0<\mu<s<\infty\\0,otherwise\end{cases}$$

Where s is the step size in the random walk process; L(s), L(γ) and L(μ) represent the probability of step size s, γ and μrespectively. Gamma is the order of magnitude; μ is the smallest step. As s goes to ∞, the formula becomes as follows:

$$L(s,\gamma,\mu)=\sqrt{\frac{\gamma}{2\pi}}\frac{1}{s^{3/2}}$$

In the case of s →∞, the inverse integral of L(s) is estimated as:

$$L(s)=\frac{\alpha\beta\Gamma(\beta)\sin(\pi\beta/2)}{\pi|s|^{1+\beta}},s\to\infty$$

Where is the Ganmma function. When z and n are equal and both integers $\Gamma(n)$=(n-1)!

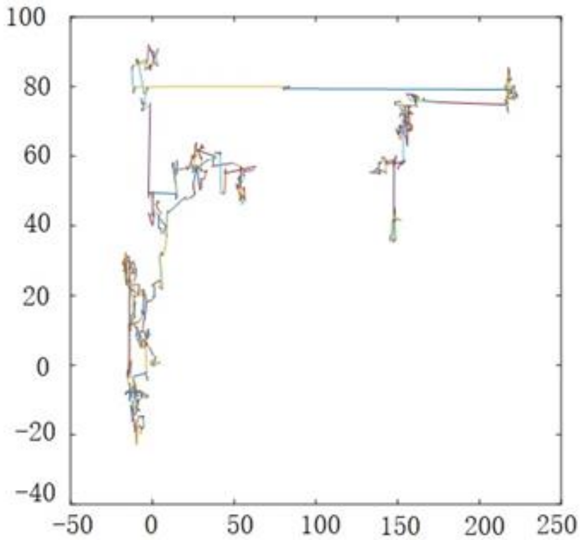

Fig 1. Levy distribution

2.2. Operation steps of Cuckoo algorithm

The CS algorithm derived from cuckoo reproduction phenomenon is carried out in two search stages: global search and local search. Global search is designed to solve the optimization problem by population renewal based on Cuckoo Levy flight principle. Local optimal is mainly optimized by using the specified formula. It is characterized by few operation parameters, simple operation, strong global optimization ability of data search, and easy to mix with other algorithms. At present, three ideal states are assumed, which are as follows:

(1) Under ideal conditions, cuckoo finds a nest and produces only one egg in the nest, and the process of finding the host nest is random;

(2) When the cuckoo chooses the nest of the host arbitrarily, it will look at the location of the nest of the next host, and save the nest with better conditions for the next breeding;

(3) Assuming that the total number of breeding cuckoos is a quota, the number of host nests available for each breeding is fixed. Under certain conditions, the cuckoo has a zero to one chance of being detected by the nest owner. Once a bird's nest owner discovers that the eggs residing in his nest are not self-producing, one of two things can happen: In the first case, the host bird identifies the eggs produced by itself, identifies the eggs of the invader, and throws or eats the cuckoo's eggs from the nest; in the second case, the host bird abandons its own eggs and the nest together and chooses a new location for nesting in another place, which indicates that there is a certain probability of the replacement of the host bird's nest.

If the above three assumptions are met, cuckoo only produces one egg in a single host nest, which determines that the meaning of cuckoo egg, cuckoo bird, and nest in this breeding situation is the same. Scholars have linked the phenomenon of cuckoo reproduction and survival with the optimization process of CS algorithm. Firstly, cuckoo birds search for nests through Levy flight, and then produce cuckoo eggs in the host nests. The process of locating and finding nests to lay eggs is defined as the global search stage of CS algorithm. When the bird's nest owner finds the foreign invasive bird's egg, he throws the cuckoo's egg, which is equivalent to the local search stage. In the algorithm, the fitness function is used to evaluate the quality of the bird's egg, which means that the higher the fitness of the bird's egg, the higher the survival probability, and the optimal solution will be closer to the ideal value.

The first step is to set the parameters and initialize the population. It includes the setting of algorithm parameters, such as the population size N, step size expressed as α, probability p, and then start to initialize the population.

The second step is to set the conditions for the termination of the program. That is, the optimal solution appears when the program runs or not reaches the maximum number of iterations;

The third step is population renewal

Before the program runs to the optimal solution, all the individuals will be replaced by the next new individual. For example, the position of the ith individual in generation t is expressed as X_i^t, Its position is updated as follows:

$$X_i^t = X_i^{t-1} + \alpha \oplus Levy(\lambda)$$

In the equation, $\oplus$ represents point-to-point multiplication, and α>0 is the step parameter related to the optimization problem scope size, which is constant in most cases. However, in order to adapt to the solution of multi-dimensional problems, α can be considered as a vector, generally acceptable 0.01, through the following formula to calculate:

$$\alpha = \alpha_0 (x_j^t - x_i^t)$$

Step four: Choose better

Selective selection, that is to say, in evolution, the fitness values of the parent and child individuals are compared, and the individuals with high fitness values are retained to the next generation, in order to make the iterative process develop in a better direction.

Step 5: Random migration

In random migration, the moving step size of Wright distribution is taken as a reference as follows:

$$Levy \sim \mu = t^{-1-\beta} (0 < \beta < 2)$$

In order to make full use of the information provided by the current optimal individuals, the complete levy flight operator is as follows.

$$\alpha_0 (x_j^t - x_i^t) \oplus levy(\beta) \sim 0.01 \frac{\mu}{|v|^{\frac{1}{\beta}}} (x_j^t - x_i^t)$$

Where: μ and ν obey normal distribution;

3. Conclusion

This paper provides a basic principle for data processing of Cuckoo algorithm, and also lays a solid foundation for the improvement of Cuckoo algorithm. At a time when many optimization methods are evolving, the cuckoo algorithm can be considered for practical engineering applications.

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