1-15

Artificial Bee Colony Algorithm with Two Kinds of Colonies

Yudai SHIRASAKI, Yoko UWATE and Yoshifumi NISHIO
(Tokushima University)

1. Introduction

Artificial Bee Colony (ABC) is known as a optimization technique by modeling the intelligent foraging behavior of honeybee swarms.

In this study, we propose Artificial Bee Colony with Two Kinds of Colonies (ABCTKC). It has different characteristic each colony. We investigate the performance of ABCTKC for four benchmark functions.

2. The flow of ABCTKC

ABCTKC has two types colonies. $Colony1$ is same searching method as ABC. $Colony2$ searches by using informations of $Colony1$. And, $Colony2$ has the characteristic of high convergence by assembling $Colony2$ to center of $Colony2$. ABCTKC can efficiently search by combining two types colonies.

Step 1 (Initialization)
Let a generation step $t = 0$, the converge step $t_{Ri} = 0$ and the exchange step t_e. After the employed bees are divided two colonies. The employed bees $i = (1, 2, ..., M_e)$ search food sources at random.

Step 2 (Search by employed bee)
Employed bees search new food source in each colony.
(Colony1)
In order to search better food source, the employed bee uses the following equation:

$$X_{id}(t+1) = X_{id}(t) + \Phi_{id}(X_{id}(t) - X_{kd}(t)) \quad (1)$$

where $\boldsymbol{X}_i(t) = (x_{i1}, x_{i2}, ..., x_{id})$ is position informations of employed bees. $k \in \{1, 2, ..., M_e\}$ is randomly chosen indexes for each colony. Although k is determined randomly from excluding the chosen i. Φ_{id} is a random number between [−1,1]. d is number of dimensions.
(Colony2)
In $Colony2$, employed bees use the searched information of $Colony1$. The searching method of employed bee is described by the following equation:

$$\begin{aligned} X_{id}(t+1) =_{id} (t) + rand[0,1](X_{id}(t) - X_{best,d}(t)) \\ - rand[0,1](X_{id}(t) - X_{ave,d}(t)) \end{aligned} \quad (2)$$

where $X_{best,d}(t)$ is the best food source in current generation t into $Colony1$. $X_{ave,d}(t)$ is the average position of whole $Colony2$.

Step 3 (Evaluation of employed bee)
Evaluate $\boldsymbol{X}_i(t)$ and compare of the current employed bee fitness value $f(\boldsymbol{X}_i(t))$.
If $f(\boldsymbol{X}_i(t)) \leq f(\boldsymbol{X}_i(t+1))$: Let $t_{Ri} = t_{Ri} + 1$.
If $f(\boldsymbol{X}_i(t)) > f(\boldsymbol{X}_i(t+1))$: Update the position information on each $\boldsymbol{X}_i$, and $t_{Ri} = 0$.

Step 4 (Search by onlooker bee)
Onlooker bee searches new food sources depending on evaluation values of employed bees. The chosen probability P_i is calculated by the following equation:

$$P_i = \frac{f(X_i)}{\sum_{n=1}^{M_g} f(X_n)} \quad (3)$$

The searching methods of onlooker bee is described by following equation:

$$Y_{jd}(t) = X_{id}(t) + \Phi_{id}(X_{id}(t) - X_{kd}(t)) \quad (4)$$

where $\boldsymbol{Y}_j(t) = (x_{i1}, x_{i2}, ..., x_{id})$ is position informations of onlooker bees.

Step 5 (Evaluation of onlooker bee)
If $f(\boldsymbol{X}_i(t)) \leq f(\boldsymbol{Y}_j(t))$: Let $t_{Ri} = t_{Ri} + 1$.
If $f(\boldsymbol{X}_i(t)) > f(\boldsymbol{Y}_j(t))$: Update the current food source $\boldsymbol{X}_i$ to new food source $\boldsymbol{Y}_j$, and $t_{Ri} = 0$.

Step 6 (Search by scout bee)
If $T_{limit} < t_{Ri}$, initialize $\boldsymbol{X}_i$ and $t_{Ri} = 0$. New $\boldsymbol{X}_i$ is searched at random by scout bee.

Step 7 (Exchange of employed bee)
If $T_e \geq t_e$: Exchange employed bee between colonies and $t_e = 0$. The selection probability E_i is calculated by the following equation:

$$E_i = \frac{(\frac{1}{T_{Ri}})^3}{\sum_{n=1}^{M_g}(\frac{1}{T_{Ri}})^3} \quad (5)$$

Step 8
Let $t = t + 1$, go back to [Step 2] and repeat until $T = t$.

3. Simulations

In order to investigate the performance of ABCTKC, we apply to four benchmark functions for $d = 20$. The simulation is 100 times and the generation number is $T = 10000$ times. ABCTKC uses best parameters each function.

As shown in Table 1, ABCTKC is better results than ABC in Sphere and Rosenbrock functions. In Rastrigin function, because the difference of Max and Min in ABCTKC is smaller than ABC's, ABCTKC obtains better results with small number of trials. From these results, we confirmed that ABCTKC can efficiently search by combining two type colonies.

Table 1: The simulation results of ABC and ABCTKC for four functions.

Function	Algorithm	Ave	Min	Max
Sphere	ABC	8.71E-255	4.34E-261	4.65E-253
	ABCTKC	$\mathbf{4.33E-289}$	4.82E-300	3.21E-251
Rosenbrock	ABC	1.29	0.78	2.01
	ABCTKC	**0.94**	0.47	1.42
Rastrigin	ABC	**0.25**	0	18.7
	ABCTKC	0.8	0	3.19
Griewank	ABC	0	0	0
	ABCTKC	0	0	0

4. Conclusions

In this study, we have proposed Artificial Bee Colony with Two Kinds of Colonies. We have confirmed that ABCTKC obtains better result than ABC for some functions. In future works, we would like to apply to higher dimensions and confirm new behaviors.