2019 International Symposium on Nonlinear Theory and Its Applications
NOLTA2019, Kuala Lumpur, Malaysia, December 2-6, 2019.

Modification of Artificial Bee Colony Algorithm under Time-Varying Condition

Ken Kamiyotsumoto†, Yoko Uwate†, Thomas Ott‡ and Yoshifumi Nishio†

†Dept. of Electrical and Electronic Engineering, Tokushima University
2-1 Minami-Josanjima, Tokushima 770–8506, Japan
Email: {kamiyotsumoto, uwate, nishio}@ee.tokushima-u.ac.jp
‡Zurich University of Applied Sciences
Einsiedlerstrasse 31a, 8820 Waedenswil, Switzerland
E-mail: thomas.ott@zhaw.ch

Abstract—Recently, nature-inspired metaheuristic optimization algorithms such as Artificial Bee Colony Algorithm (ABC) is developed. ABC is based on the feeding behavior of bee herds. ABC can not solve for time-varying function.

In this study, we offer a new ABC for time-varying function. We propose ABC in which the scout bee is improved probability by normal distribution. We compare the best solution with ABC, previous method and the proposed method. Object function which optimal solution moves circle of shape is used. We investigate characteristic of proposed method according to variance of normal distribution. Best value and orbit of solutions for proposed method are better than those of other method.

1. Introduction

Optimization is to search optimal solution under condition. Benefit of optimization is high efficiency. Optimization is needed in various scenes. Combinatorial optimization problem is often solved by metaheuristic optimization algorithms.

Many combinatorial optimization problems often results in local optima. Metaheuristic optimization algorithms are provided good-quality solutions which are close to the optimal solution with less computational effort in these problems. These algorithms are developed to solve more efficiency and larger problems. Metaheuristic optimization algorithms have Evolutionary Algorithm (EA), Swarm Intelligence (SI) algorithm, local search, etc. In our study, we choose the SI.

SI is one of the artificial intelligence techniques. SI was born from swarm of insect. Examples existing in nature are ant, bee and firefly, etc. In insect colonies, each insect has its the group in total appears to be highly organized. The applications of SI technique are a self-driving car and data mining. The good points of this technique are smaller control system and multi control by simple systems. SI algorithms have Artificial Bee Colony Algorithm (ABC), Ant Colony Optimization (ACO), Particle Swarm Optimization (PSO), Firefly Algorithm (FA), etc [1]. The ABC is used by our propose method.

ABC is idealized the social behavior of bees based on their feeding characteristics. ABC was proposed by Karaboga Dervis in 2005 [2]. Artificial intelligence algorithms have been demonstrated to show effectiveness and efficiency to solve difficult optimization problems [3]. ABC performs higher ability in high dimensional optimization problem than other SI algorithms. However, demerit of ABC is that it can not search time-varying function.

In previous study, we modified ABC for time-varying function (ABCTV) [4]. However, we can not find accurate solution. [5]

In this study, we propose ABCTV in which the employed bee is improved by predictive value. We compare the best value of the solution with ABC, ABCTV and the proposed method.

2. Artificial Bee Colony Algorithm

Karaboga has proposed an Artificial Bee Colony (ABC) algorithm in 2005. The ABC algorithm is based on real bee behavior and consist of 3 kinds of honeybee, employed bee, onlooker bee and scout bee. It is suitable when the object function is high dimension [6]. The procedure for solving an optimization problem in the ABC algorithm is shown below.

Step0.

Initialize each total number of employed bees n_e and onlooker bee n_o, the colony size $N = n_e + n_o$ and the total number of iterations t_{max}.

Step1.

(1) Set the locations of the x_i. i is the number of the employed bee.
(2) Calculate the fitness f_i in the initial arrangement by Eq. (1). The best f_i and initial arrangement are stored.

Step2.

(1) New locations v_i is generated by Eq. (2) and calculated the fitness function value.

(2) Based on the fitness, the best location and fitness update.

step3.

(1) Based on the fitness, the probability p_i is calculated by Eq. (3).
(2) Select the number of employed bee i based on p_i, and Step1 is applied. When this procedure has been repeated n_o times.

step4.

If function value of each i is better than function value of all bees, the solution and the function best value are updated.

step5.

The employed bee which has not been generated the new location.

Step6.

Repeat steps 1 to 4 and output the solution.

Fitness function f_i and probability p_i are given by following equations:

$$f_i = \begin{cases} \dfrac{1}{1+g(x_i)} & if\ g(x_i) \geq 0 \\ 1+|g(x_i)| & otherwise \end{cases} \tag{1}$$

$$v_{ij} = \begin{cases} x_{ih} + \phi(x_{ih} - x_{mh}) & if\ j = h \\ x_{ij} & otherwise \end{cases} \tag{2}$$

$$p_i = f_i / \sum_{i=1}^{n_e} f_n , \tag{3}$$

where, $g(x_i)$ expresses the objective function. Figure 1 shows flowchart of ABC.

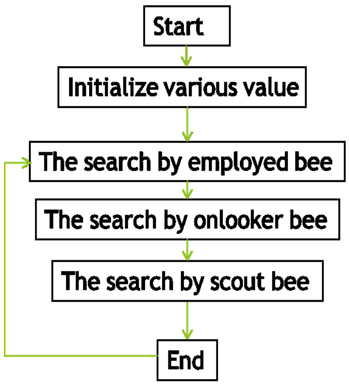

Figure 1: flowchart of ABC.

3. Previous method [4]

The most of algorithms exclude time-varying solution. However, when we search optimal solution, we need to apply the both solutions (time-varying and not time-varying). In case of ABC, it can not be performed adapted to environmental changing such as shifts in the optimal solution or variations of the cost function. The artificial bee colony algorithm for time-varying solution (ABCTV) is proposed. ABCTV was modified 2 points. First, when employed bee compares fitness function values between 2 locations, previous location is reevaluated for each simulation count. Second, we calculate best fitness function value for each simulation count.

According to these modification, ABCTV can search time-varying solution. However, ABCTV can not search accurate solution than the standard ABC. Figure 2 shows flowchart of ABCTV.

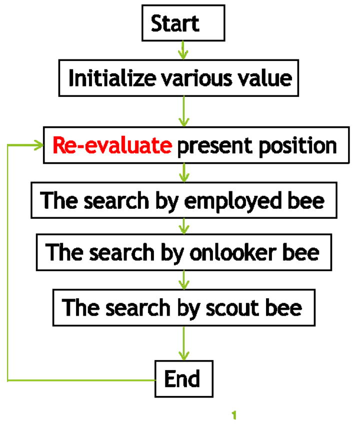

Figure 2: Flowchart of ABCTV.

4. Proposed method

We propose ABCTV in which the employed bee improves by prediction. The employed bee searches a new location by Eq. (1) in the standard ABC. However, ABC has problem point that the best solution follow for optima. Therefore, we modify that the employed bee searches new location by the prediction position. The prediction position is calculated difference of the employed bee between current best location and the previous best location. According to we assume the optimal solution is uniform motion, we predict the location of the next optimal solution from the difference between the two locations. Furthermore, we use equation of PSO to append the predictive value. In PSO, position is calculated by Eq. (4).

$$v_{ij} = x_{ij} + \phi(x_{ij} - x_{kj}) + \psi(y_j - x_{ij}), \tag{4}$$

where y_j is information of global best solution and x_{kj} is information of local best solution. PSO use information of global best solution to guide searching. This convert the predictive value. From the beginning of the simulation employed bee searches new location by using Eq. (5).

$$v_{ij} = \begin{cases} x_{ih} + \phi(x_{ih} - x_{mh}) + \psi(x_p - x_{ih}) & if\ j = h \\ x_{ij} & otherwise \end{cases} \tag{5}$$

Table 1: Simulation results (time-varying)

α	0.01	0.05	0.10	0.15	0.20	0.25	0.30
ABC	1.08e-08	1.11e-06	4.11e-06	4.51e-06	3.12e-06	4.55e-06	6.08e-06
ABCTV	4.12e-07	3.34e-06	9.96e-05	7.33e-05	2.96e-04	1.43e-04	2.77e-05
proposed method(C=0.5)	2.26e-07	6.47e-06	6.75e-06	3.33e-05	2.62e-06	6.53e-06	1.56e-05
proposed method(C=1.0)	9.21e-08	3.84e-07	3.90e-07	6.39e-06	5.94e-06	1.07e-05	5.96e-05
proposed method(C=2.0)	1.55e-08	4.35e-07	8.59e-06	7.12e-06	2.92e-05	1.33e-05	6.71e-06
proposed method(C=3.0)	4.28e-09	4.28e-09	3.52e-06	1.05e-05	9.34e-07	4.01e-07	7.16e-06
proposed method(C=4.0)	4.31e-08	1.18e-06	1.99e-06	1.06e-05	3.16e-05	3.88e-06	1.56e-05

ψ is a uniform random parameter in [0,C], where C is a nonnegative constant. In this study, we set 5 kinds C (0.5, 1.0, 2.0, 3.0, 4.0).

5. Simulation results

Firstly, in order to evaluate the performance of the propose method, we compare the result of Eq. (6).

$$g(x_1, x_2, k) = 1 - \exp[-\frac{(x_1 - 250 - 125\sin\alpha k)^2}{2 \cdot 40^2} - \frac{(x_2 - 250 + 125\sin\alpha k)^2}{2 \cdot 40^2}]. \quad (6)$$

Figure 3 shows the shape of this function.

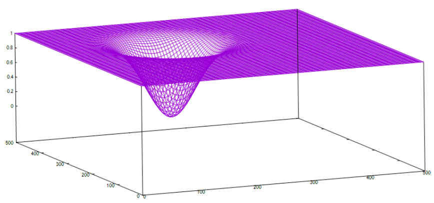

Figure 3: shape of time-varying function.

Equation (6) simulates a visual tracking problem. The distribution of the minimum value represented by a Gaussian function moves continuously in the figure, and the problem of tracking this movement is assumed. The optimal function value is 0, and position along a circle of radius 125 centered at $(x_1, x_2) = (250, 250)$, then return its original position in $(2\pi/\alpha)$ steps. k means time that is approximated by simulation count. We express the constant value to use for simulation in Eq. (7).

$$n_e = n_o = 50, \ t_{max} = 100000 \quad (7)$$

We compare the best value for 7 kinds movement speed of optimal solution α (α = 0.01, 0.05, 0.10, 0.15, 0.20, 0.25, 0.30). The best solution is the smallest value in results of 15 times simulations. Table 1 shows that the best value of each method. From Table 1, the best value of the propose method is better than the best value of ABCTV. Especially, the propose method when C = 3.0 has best performance. However, many of the proposed methods become less effective as α increases. This is reason that the movement of the solution becomes discrete as α increases.

Secondly, we confirm that the proposed method has the ability to search for not time-varying solutions. We use the three benchmark functions in Table 2.

Table 2: Benchmark functions

function	Name
$\sum_{n=1}^{D} x_n^2$	Sphere Function
$\sum_{n=1}^{D}(x_n^2 - 10cos(2\pi x_n) + 10)$	Rastrigin Function
$20 - 20exp(-0.2\sqrt{1/n\sum_{n=1}^{D} x_n^2} + e - exp(1/n\sum_{n=1}^{D} cos(2\pi x_n))$	Ackley Function

Figure 4, 5 and 6 show the shape each function. Table 3 shows that the best value of propose method (C=3.0) for not time-varying environment.

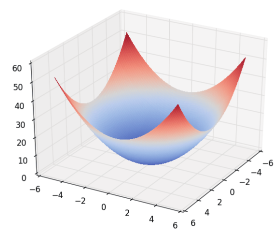

Figure 4: Sphere function.

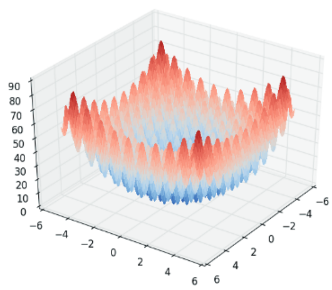

Figure 5: Rastrigin fuction.

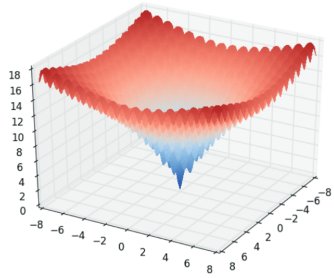

Figure 6: Ackey fuction.

Table 3: Simulation result (not time-varying)

dimention	10	30	50
Sphere	0	6.44e-243	6.11e-48
Rastrigin	17.39	92.80	189.34
Ackley	12.11	19.23	19.94

From Table 3, propose the method can search not time-varying solution.

6. Conclusion

This paper shows the ABC modified that employed bee is changed by predictive value because this algorithm do not applied for accurate time-varying solution. We tried improvement of ABC, where employed bee searches new position by predictive value. The predictive value is calculated by difference between best solutions by assuming that optimal solution is constant motion. Furthermore, the predictive value is append searching equation of employed bee by inspired from PSO. We set propose method has 5 kinds of range of random value. We compared the best values of proposed method, previous method and ABC. As a result, even if optimal solution is discrete, proposed method could search better value than other algorithms. Therefore, propose method is better performance than other methods.

In the future work, we would like to investigate the mechanism of the proposed method in detail. Furthermore, we try to search high dimensional problems.

References

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

[2] D. Karaboga, "An idea based on honeybee swarm for numerical optimization," Technical Report TR06, 2005.

[3] I. Iimura and S. Nakayama, "Search Performance Evaluation of Artificial Bee Colony Algorithm on High-Dimensional Function Optimization," Transactions of the Institute of Systems, Control and Information Engineers, vol. 24, pp. 97-99, 2011.

[4] T. Nishida, "Modification of ABC Algorithm for Adaptation to Time-Varying Functions," Electronics and Communications in Japan, vol. 96, 2013.

[5] K. Kamiyotsumoto, T. Ott, Y. Uwate and Y. Nishio, "Artificial Bee Colony Algorithm for Time-Varying Optimization," Proceedings of RISP International Workshop on Nonlinear Circuits, Communications and Signal Processing (NCSP'19), pp. 382-385, 2019.

[6] W. Y. Szeto and Y. Wu and S. C. Ho, "An artificial bee colony algorithm for the capacitated vehicle routing problem," European Journal of Operational Research, vol. 215, pp. 126-135, 2011.