Parameter tuning for artificial Bee Colony algorihtm

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***Abstract*— Artificial Bee Colony algorithm (ABC) is one of the popular swarm intelligence that widely used in working out on intricate problems. It is the algorithm that is mainly used in this paper. It can be observed from ABC that settings of parameters can affect the performance of the algorithm. Setting a parameter in an overly or slightly manner can lead to counter effect. There is no one universal resolution in the setting of algorithm parameter. Notwithstanding that, it is feasible to tweak the parameters with the aim of looking for the best fitting solution for a particular problem. The problem that is being focused on in this paper is 60 queen problem. The objective of this research is to study the impact of the parameters in solving N-queen problem by employing Artificial Bee Colony algorithm (ABC). This research alters the parameters in ABC and records the experimental output. Two parameters are researched, which are the swarm size and limit. To Fine-tuned parameters in solving any problem are proposed in this paper. The findings of this research are considerable.**

***Keywords*— *Artificial Bee Colony, N-queens, population size, limit,* Scout bee phase**

I. Introduction

Artificial Bee Colony (ABC) is a metaheuristic algorithm that has been applied by many researchers in tackling combinatorial optimization problem and non-linear functions. ABC is a natural inspired algorithm that introduced by D. Karaboga. The algorithm imitates the foraging behavior of bees and the key success factor of this kinds of algorithm is self-organization. The collective behavior of individual in a decentralized swarm is to fulfil a global task [4]. As the complexity and difficulty of optimization increases in real world, the algorithm with better optimization ability is demanding. Thus, many researchers have conducted studies on ABC to modify the algorithm with the purpose of improving its performance.

No matter in which variants of ABC, control parameters are required to resolve the searching behavior of bees in a swarm which include the swarm size, limit and maximum cycle of foraging process. Nonetheless, setting an optimal parameter for the algorithm to perform well can be rough. A set of parameters that lead to the optimal solution in one specific problem can be inappropriate for other set of problems. Even the setting that is optimal at the start of searching can fail in the next appraisal of the same algorithm Thus, parameter setting of the algorithm need to be generally optimal and robust to perform well [1]. Few researches have done to analyze the impact of parameters on affecting the performance of ABC.

In 2007, [3] analyzed the performance of ABC under the different parameter setting. The parameter of swarm size is set as 10,50, and 100 to test on 5 benchmark functions while the limit parameter which has the impact of the production of scout bee is set with the function of 0.1*ne*D, 0.5*ne*D, ne *D and “without scout” which means 0 of limit parameter. From this study, the conclusion is made where the increment of swarm size can only increase the effectuousness of the ABC until certain level where the continuously increment on it after certain threshold does not benefit the performance at all. For the limit parameter, the limit value that produces with the parameter of 0.1*ne*D and 0 will result in more scout bees are produced. More scout bee produce is then result in poor outcome compared to the moderate setting of limit parameter by using other two functions. Also, the changing in limit parameter only make visible improvement in small swarm size and multimodal functions [3].

In 2008, similar studies were done by [7] to analyze how does the accuracy of optimum value is affected by the parameter of number of food source. The study is conducted by applying ABC algorithm on three different benchmark functions with the parameter of 10, 20 and 50 of number of food source. According to this study, it can be concluded that the larger number of food source can improve the accuracy of optimum value produced [7].

In 2016, [2] proposed a journal which studies the impact of number of food source on the performance of ABC. In this study, ABC algorithm is tested on 35 various benchmark problems with the population size setting that ranging from 10 to 1000. According to the studies, the performance of ABC algorithm can be ameliorated by amplifying the food source size. However, negative impact can arise when the population size bypasses a certain threshold. Also, each benchmark functions produce different results on the same parameter setting. Thus, fine tuning is required for every problem to get a well-fitted optimal parameter setting that give the best result [2].

In this paper, the parameter tuning of ABC algorithm will be studied. Different population size and limit parameter are tested to find out the optimal parameter for ABC algorithm in solving 60-queen problem and analyze how the parameter changing affect the performance of the algorithm.

II. MATERIALS AND METHODS

A) Artificial Bee Colony

1) Initialization of swarm

The artificial bee algorithm has three parameters which play pivotal roles in the algorithm. They are the population, which is the number of food sources, limits, which is the number of trials and the criteria to terminating, which is otherwise identified as the maximum number of cycle. In the primeval ABC that has been initiated by D. Karaboga, the finest outcomes present when the number of employed bee phases along with the onlooker bees are halved which is equivalent to one half of the primary population. To equitably distribute the preliminary population is recommendable. Every single food source is exemplified by a D-dimensional vector Xi (i = 1, 2 ...SN). Food source is begotten respectively through equation (1)

$$x_{ij} = x_{min\ j} + rand[0,1](x_{max\ j} - x_{min\ j}) \qquad (1)$$

Rand [0,1] is a function that haphazardly produces a number in the range in between 0 and 1 [2][4].

2) Employed Bee Phase

Employed bees remodel the existing solutions by means of the intelligence of an individual's understandings as well as the aptness of the lately discovered solution. The modern food source that possesses larger fitness value substitutes the existent food source. The equation to renovation for jth dimension of ith candidate in this phase is [2][4].

$$v_{ij} = x_{ij} + \emptyset(x_{ij} - x_{kj}) \qquad (2)$$

From the equation, it is distinguished as the step size. J and K are both indices that are picked indiscriminately. Also, k does not match with I for the purpose of assuring there are enormous ameliorations in the step size [2][4].

3) Onlooker Bee

Onlooker bees has an equal amount of bees as the employed bees. Plus, the quality of the food source is represented in terms of fitness. Info regarding the fitness of new food sources is informed by the employed bees to be utilized by the onlooker bee. Onlooker opts for food source according to the fitness of food source which has to supreme. There are a number of approaches to compute the eventuality. On the other hand, fitness must be put into consideration in the approach. The probability for the fitness of each food source can be judged by the following equation [2][4].

$$P_{ij} = \frac{fit_i}{\sum_{i=1}^{SN} fit_i} \qquad (3)$$

4) Scout bee phase

The scout bee operates at the time when a food source is not revamped for a preset number of iterations, and that food source is forsaken. The scout bee is initially the employed bee for the abandoned food source is converted as a scout bee and perform exploration by choosing a new food source at random. The newly found food source takes over the renounced food source. The equation applied with the intention of getting new food sources is as follow [2][4].

$$x_{ij} = x_{min\ j} + rand[0,1](x_{max\ j} - x_{min\ j}) \qquad (4)$$

From the above discussion, summarization can be made. As in the ABC algorithm has three substantial parameters, including the maximum number of cycles, the food sources amount, and limit [2][4].

B) Tetsing hardware

In order to ensure the accuracy of the experiment output, only one laptop is used to perform the experiment. The computer used to run the test in this paper is Asus Rog Strix G. The specification of the computer is as follows, i7-9750H, RTX2070 along with 16 gb of ram. The computer is plugged in all the time in running the experiment to assure that the outcome is not deviated. The programming used to run the source code is Java with NetBeans as the IDE.

C) Algorithm implementation

As to study the impact of parameters of ABC on its performance, the N-queen problem is implemented to solve by ABC. N-queen is one of the classical combinatorial problems which widely used in testing the effectuation of an algorithm in solving a problem. The goal of N-queens is to allocate N number of queens on a N*N chessboard in a way that only one queen is allowed in each horizontal, vertical, or diagonal line [1]. Since a queen is allowed to move in any direction to achieve the goal, lots of arrangements are possible to produce. Thus, N-queen problem is computationally demanding as it is hard to get the unique solution from large set of possible arrangements [2].

With the intention to implement ABC algorithm in solving N-queen problem, a population of N-queen chessboards are generated during the initialization. The board will be generated by first placing all the Queens in a diagonal manner where only a Queen is available in each row, and the Queen in ith row will be placed on ith column to avoid horizontal and vertical conflicts. Then, each board will be randomly shuffled by arbitrary selecting two queens for several times and swapped the row value of their positions. Besides, to work with N-queen problem, N that represent the number of parameters of the board to be optimized need to be identified.

In the employed bee phase, instead of using the normal distribution between [-1,1] to calculate the step size for the exploitation process, ϕ is replaced by \phi_{ij} which refers to the subtraction of 0.5 from a random generated number in the range of [0,1] which later multiply by 2. Thus, a new neighbor food source is generated by swapping the position of two queens according to the calculated value. Besides, to implement the ABC in solving N-queen problem, the comparison between newly developed neighbor food source and current food sources is made by comparing their conflict values. New food source will only be selected if it has a lower value of conflicts.

The fitness value of each food source is calculated according to their conflict values, where the fitness value of each food source is computed by using the following equation.

$$fit_i = (\max(\{f(x): x = 1,\dots,SN\}) - f(i)) * 100/min(\{f(x): x = 1,\dots,n\}) \quad (5)$$

Where SN refers to the number of food sources and f(x) is used to compute the conflict value of the food source. f(i) is referred to the conflict value of the current food source. According to the fitness value, selection probabilities value of each food source can be computed by using the following formula.

$$P_i = 0.9 * (fit_i / max(\{fit(x): x = 1,\dots,SN\})) + 0.1 \quad (6)$$

The higher the fitness value of a food source, the higher the value of the selection probability of a food source. Thus, a food source has a higher probability to be chosen by the onlooker bees for exploitation.

The best food source is memorized, which refers to the N-queen board with the lowest number of conflict values. In this study, epoch parameter, which refers to the number of foraging cycles is set to 1000, where the foraging process on a set of food sources is terminated if no solution is found within this parameter. The whole foraging process is repeated several times on a different set of food sources where the program will only stop if it gets either 50 of success foraging process or 100 of failure foraging process on a different food source set.

For the purpose of studying the impact of the parameter on the result of ABC and finding the best optimal set of parameters for this N-queen problem, the whole process mentioned above is repeated in a different number of swarm size and limit parameter. The swarm size that was being tested includes 10, 50, 100, 200, 300, 500, and 1000 while the limit comprises 10, 50, 100, 250, and 500. Modification on swarm size has an impact on the population size, which is also known as the number of food source as it is set as the half of the swarm size. Other parameters are fixed where the epoch is set as 1000, and the N for N-queen is set as 60.

III. RESULT AND DISCUSSION

The result shows the average values of runtime and number of failures after executing the whole program 10 times to increase the accuracy of the result. As two parameters are changed in this study, thus each combination of these two parameters is tested.

According to the result in Table I, it can be concluded that the increment in population size can increase the performance as the number of failures decrease. When the population size increases until 200, and onwards, the number of failures is equal to zero except for the one with the extreme limit value, which is 10. This indicates that all foraging process on a different set of food sources are successfully come out with the solution of N-queen within the epoch parameter. However, during the increment of swarm size, runtime also increases extensively except for the swarm size of 300 where the runtime value is similar to the average runtime for swarm size of 10 and 50, but it has a better outcome when compared with them in term of the number of failures. Thus, 300 of swarm size is identified as an optimal setting of swarm size in this problem. As mentioned by [3], once the required amount of swarm size is reached, which is 200 in this case, the increment of swarm size does not make any improvement. Thus, it is essential to know the optimal setting to avoid setting huge value of swarm size, which does not help in improvement but only degenerate the performance as mentioned by [4].

TABLE I. RESULT OF ABC ON N-QUEEN PROBLEM ON 35 DIFFERENT COMBINATIONS OF PARAMETER

Swarm Size	Limit	Average runtime (sec)	Number of failures
10	10	103.8	100
	50	144.8	81.1
	100	131.8	76.6
	250	131.5	77.6
	500	130.6	76.3
50	10	556.5	100
	50	209.2	5.5
	100	206.5	3.5
	250	194.6	1.8
	500	192.7	2.5
100	10	1006.2	100
	50	326.3	0.9
	100	310.3	0.2
	250	310.4	0.1
	500	326.8	0.1
200	10	1985.3	100
	50	584.8	0
	100	541.2	0
	250	552.3	0
	500	535	0
300	10	926.5	100
	50	246.2	0
	100	239.5	0
	250	234	0
	500	246.3	0
500	10	1508.9	100
	50	381.7	0
	100	430.5	0
	250	366.2	0
	500	366.4	0
1000	10	3060.1	100
	50	685.7	0
	100	656.8	0
	250	654.5	0
	500	656.9	0

According to [3], the parameter limit will affect the generation of scout bee to search for a new solution in the search space. The lower the value of the limit, the higher possibilities that scout bees are produced to search. According to the result, it can be concluded that the greater the limit, the greater the result in terms of both average runtime and number of failures. However, the improvement is only evident in a small swarm size. As the swarm size increases, the increment in limit does not seem to make any meaningful improvement on the result. One significant observation that can be made is when the limit is set as 10. With the value setting of 10, the average runtime and number of failures increase extensively no matter what the value of swarm size is because the scout bees will be activated more frequent as mentioned by [3]. Thus, from the result showed, an optimal set of parameters can be identified to solve the N-queen problem with the highest efficiency and performance, which is when the swarm size is set as 300, and the limit is set as 250. Limit has a pronounced impact in all the swarm size when the value passes a certain threshold. This research study is not without its limitation. Although the optimal swarm size and limit parameter are determined for 60 queen problem, there are still other parameters that can be study to further remodel the performance of ABC on the problem.

IV. Conclusion

In conclusion, the performance of ABC in different parameter setting is analyzed. Parameter affects the outcome tremendously. The analysis result shows that ABC algorithm performs outstandingly when the parameters are set with optimal values. For the 60 Queen problem, with parameter of 300 swarm size and 250 limit, the solution can be found in the shortest time. In the future research, more parameters can be analyzed to understand how other parameters affect the performance of ABC to get a set of parameters which is optimal and robust in solving 60 Queen problem.

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