

## **Artificial Bee Colony Algorithm and Bat Algorithm for Solving Travel Salesman Problem**

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### **Abstract**

There are many algorithms for optimization meta heuristic have developed on swarm intelligence-based that depending in the nature of design. One of them, Bat Algorithm (BA), is based on the "echolocation behaviors" of bats. Micro bat used echolocation to specify the prey, avoid obstacles and locate their roosting crevices in the dark. Another algorithm is Artificial Bee Colony (ABC) is a new optimization algorithm which depend on the "bee behavior" towards colony to search about the food. In this paper, presents the BA and ABC algorithms steps for solving TSP then try to search about best solution depending on the parameters for both algorithms. The results show the ABC is best performance than BA for finding the best tour quickly compared with other by consuming time lesser than by effecting on the convergence speed for searching the solution.

Furthermore, The BA required more parameters to achieve each output efficiently and need using improved control strategy to balance between exploitation and exploration that consuming more time for it.

### **Keywords**

Bat Algorithm, Artificial Bee Colony, Traveling Salesman Problem.

### **Introduction**

Meta heuristic algorithms is obtained the acceptable solutions in the specific time but not guarantee that is global best solutions which is founded. It applies in an environment with little information about the solution and achieve a balance between exploration and exploitation.

The popular meta heuristic algorithms are Tabu Search (TS), Ant Colony Optimization (ACO), particle swarm optimization (PSO), Fire Fly Algorithm (FA), Artificial Bee Colony (ABC), etc.

Optimization is the process for choosing the best values that determine some criteria from a set of possible values defines.

Recently, many algorithms and techniques is trying to solve TSP that presented by Karl Menger in 1930 to reach optimal solution because the important application of this problem in modern real life such as DNA sequence, in microchip manufacturing, logistic planning, collision avoidance in robotics etc. (Odili, 2013; Odili *et al.*, 2020).

The problem describes as, there are set of cities and there is a distance between them which represented as a cost. The optimal solution must calculated depending for each tour that start from one city then visit all the cities once time (Wong *et al.*, 2008).

TSP is Non-deterministic polynomial time hard NP –hard. the exact solution is founding all the permutation combinations with approximate solutions (Shema *et al.*, 2016; Sohil & Parikshit, 2013).

In 21<sup>st</sup> century, used optimization algorithms to solve TSP such as Bat Algorithm (BA), Cuckoo Search (CS), firefly algorithm, African Buffalo Optimization and Artificial Bee Colony (ABC) etc. (Odili *et al.*, 2020).

The ABC algorithm is an intelligence optimization algorithm's that is derived from the nature behavior of food searching by honey bees.

The "foraging behavior" of the bees is useful in the computational algorithm for solving complex problems in different domains by adopting the values (Karaboga & Basturk, 2007; Wedde *et al.*, 2004).

Bat algorithm (BA) developed by Yang, X. that works on the "echo locating" behavior of micro bats. Bats are "nocturnal animal" that can distinguish between prey using echolocation which is a type of sonar and also detect the size, speed of moving bats and distance (Yongquan *et al.*, 2013).

Also, use low loud sound pulses for searching about roosting then listen to its echo back from the objects. after that it generate "3D image" of their environment of the objects. when find a prey it regenerate a larger softer sound pulse approximately (200 per second). (Yang & Gandomi,2012).

### **Artificial Bee Colony Algorithm (ABC)**

Is a new swarm based in the optimization algorithm that discover from inspired by social behavior of honey bees in the nature, more ever, Karatage, D. (2005) is presented firstly (Odili, 2013).

There are three groups of bees (Hao, 2010):-

Scout group, on looker group and employed bees group. For each employed memories source area that previously visited and achieves a new food source that provide the higher fitness nectar the new solution than the previously. In this case, employed bee forgets the previous solution. Otherwise, employed bee save the previous each onlooker provides the information about employed bees from the dance within the hive, there is a shared information that helps to decide with the employed were abandoned, become scout, and then start randomly search in the search space like the initial solution generation (Odili *et al.*, 2020).

There are four stops criteria. firstly, memory cycle number (MCN) which is sum values of maximum number of generation, maximum number of population, dimension is the number of cities and lastly, the number of runs. The ABC depend on local search or neighborhood that moves between an initial solution with others by checking the neighborhood rules to improve the value of the objective function each time to reach a local optimal solution. The definition of neighborhood generally depend on the swapping any adjacent pair of critical operations (nodes or cities) in the same design (Chong & Malcoin, 2007).

Below the flowchart of ABC algorithm.

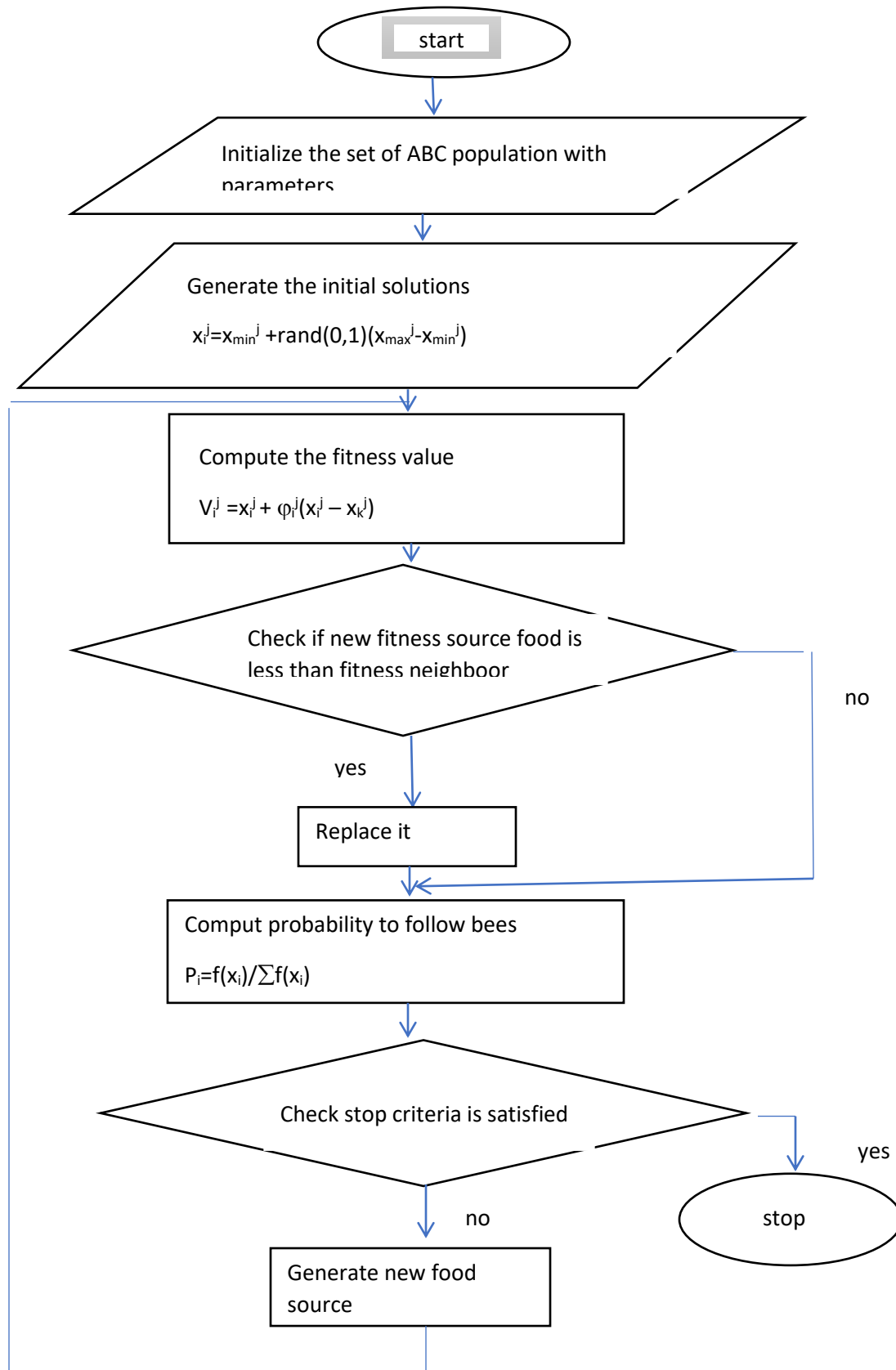


Figure 1 Flowchart for Artificial Bee Colony algorithm

## Bat Algorithm (BA)

Is a swarm intelligence based-meta heuristic algorithm, it developed by Yang in 2010, inspired by the foraging of micro bats characteristics that used echolocation to discover the distance and finding the difference between food prey and background barriers in some magical way (Kongaew, 2017).

It employs the automatic mechanism to balance between exploitations and explorations within the search space. The Bats fly within velocity randomly with fixed frequency with vary in loudness and wave length to reach for prey.

The loudness values changing from positive large value to minimum constant value (Yang & Gandomi, 2012).

Bat algorithm are use in NP-hard problem such as routing problem (TSP and VRP). This problem is popularity and importance because using in transport or logistics.

The general algorithm's steps are described below:-

Start

Step 1: initialize the bat's population

$$Y=y_1,y_2,\dots,y_n$$

Step 2: define the objective function  $f(y)$

Step 3: repeat 4 and 5 for each bat  $y_i$  in the population

Step 4: initialize the pulse rate, velocity with loudness

PR<sub>i</sub>: pulse rate

Ve<sub>i</sub>: velocity

LO: loudness

Step 5: specify the pulse frequency  $f_i$  for  $y_i$

Step 6: repeat the steps below until criteria not publishing.

Step 7: for each bat  $Y_i$

Step 8: generate new solutions by using the equation

$$F_i=f_{\min} + (f_{\min} f_{\max})^\beta \dots 1$$

$$Ve_i^t=Ve_i^{t-1} + [y_i^{t-1} - y^*]f_i \dots 2$$

$$y_i^t=y_i^{t-1} + Ve_i^t \dots 3$$

where

$y^*$ : is the current best solution.

$\beta$ : is randomly value generated in [0,1] interval.

$Ve_i^t$ : is the velocity at time t.

$y_i^t$  : is the bat  $i$  at time  $t$ .

step 9: if rand greater than  $PR_i$  then

step 10: select the one solution among the best ones.

Step 11: generate a local solution around the best one

Step 12: otherwise,if  $\text{rand} < LO_i$  and  $f(y_i) < f(y^*)$  then

Step 13: accept the new solution

$$Y_{\text{new}} = y_{\text{old}} + K LO^t \dots 4$$

Where

$K$ : random value in  $[-1,1]$

$LO^t$ : is the average loudness of the solution at time  $t$

Step 14: increase  $PR_i$  and minimize  $LO_i$

Step 15: rank the bats and return the current best bat of the population

End

When using the algorithm steps above for solving TSP, use the steps below for calculating the velocity value

$$Ve_i^t = \text{random}[1, \text{hamming distance}(y_i^t, y^*)] \dots 5$$

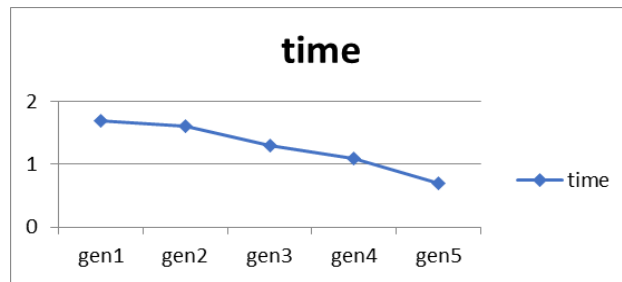
The  $Ve_i$  of the bat  $i$  at time  $t$  is a random number between 1 and the hamming distance between two best bats that is the number not corresponding elements in the sequence (Eneko *et al.*, 2016).

The position of bat  $I$  at time  $t$  depending in the creating the new two areas within current path with avoiding the sub hours. This function is named 2-opt, that defined by Lin 1965 and was used for solving TSP.

Each bat in TSP moves in different paths depending on the position of the best bat of the swarm by examine it's  $Ve_i^t$ .

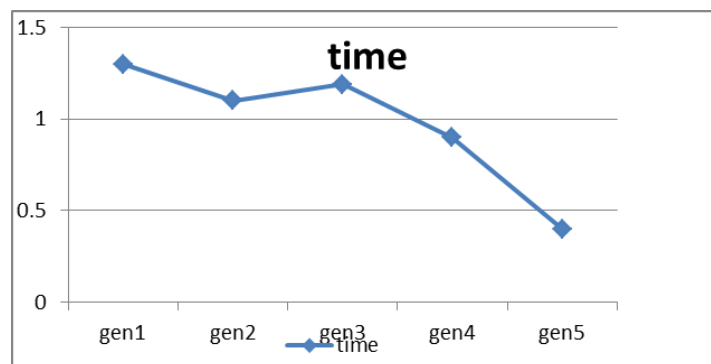
## **Experiment and Discussion**

In order to evaluate the performance of BA and ABC for solving TSP. Firstly, initialize the population size of BA with 8 cities which is equal to the number of bats, the number of generation is 5  $LO$  is 0.65,  $\beta$  is 0.45,  $PR$  is 0.15, in the software which was written in mat lab. The optimal tour solution's length that is shown in figure 5 is 27 (2 3 4 5 6 1 0 7) after five runs, the time for obtaining optimal solution is (1.7, 1.6,1.3,1.1,0.7) that are shown in figure 2.



**Figure 2 Time for optimal solution for solving TSP using BA with loudness 0.65**

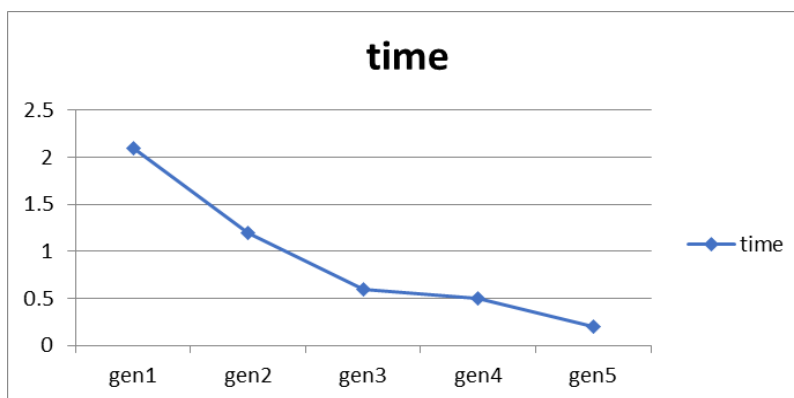
While in figure 3, display the time for best tour for five generation when using the same values above except change the LO to 0.23, the tour length is 24.



**Figure 3 Time for optimal solution for solving TSP using BA with LO is 0.23**

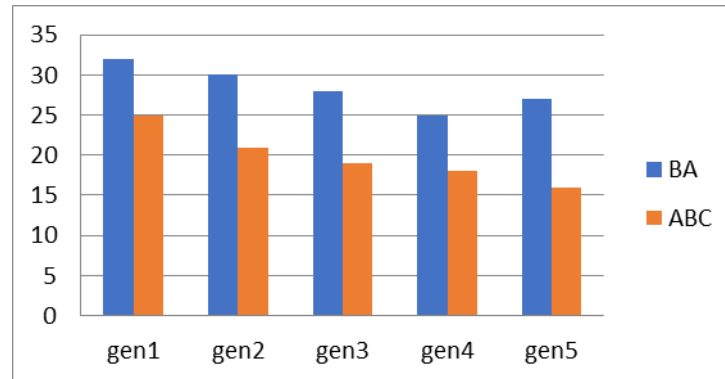
From the above figures, deduce the tour consume less time when decrease the value of loudness of the BA for solving TSP because influence on the tour length.

When apply ABC for TSP with initializing the population size with 8(food source in ABC, number of cities in the TSP), maximum number of runs is 5 which is the similar to the maximum cycle number. The time for obtaining the optimal tour is (2.1,1.2,0.6,0.5, 0.2) the length of optimal tour is 16. Figure 4 display the time for five generation.



**Figure 4 Time for optimal solution for solving TSP using ABC for five generation**

From figure 4, conduct when used more generation this lead to decrease the time for computing best tour then we deduce when perform ABC for routing problem must use the maximum number of generation because it converge easily to the optimal solution.



**Figure 5 Best tour's length for solving TSP by using AB,ABC for five generations with LO=0.65**

From figure 5, deduce the ABC is the best algorithm for searching about best tour in the routing problem than AB. it influence on the tour length which is the most important parameter for all types of routing problems.

## **Conclusion**

The parameters that is similar between AB and ABC is effect on the search about optimal solution which is number of generation with size of population. But the difference are when computing the distance between the cities in the ABC is the inverse of probability of the fitness while in bat is the velocity which computing randomly between the [1, hamming distance]. in BA, the loudness is the parameter which control the solution is regenerate back in the population then is updated by decreasing the value for each bat.

Then the ABC is better than BA because it produce a shorter tour compared to its own previous best tour that allocated to dance.

Furthermore, The BA required more parameters to achieve each output efficiently and need using improved control strategy to balance between exploitation and exploration that consuming more time for it.

I suggest in future design a system that combined two algorithm.



Firstly design Bat algorithm for solving TSP then the best tour entered as initial population to ABC algorithm for improving the choosing best tour that is nearly optimal solution.

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