Behavior of Artificial Bacteria

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ABSTRACT

In a research field, Swarm intelligence is the collective behavior in swarms of insects or animals. Several algorithms are developing from such behavior to solve a huge range of complex optimization problems. In this paper, a swarm algorithm called Bacterial optimization algorithm is proposed for solving optimization tasks. Bacterial optimization techniques are proposed based on original bacterial behavior. In this behavior, accuracy and convergence speed are improved to solve the optimization problem. Its lifecycle is based on chemotaxis, communication, elimination, reproduction and migration. Chemotaxis and communication steps run for whole optimization process but others elimination, reproduction and migration run only when condition satisfied. This paper presents the behavior of E.coli bacteria and bacteria based optimization algorithm.

Keywords: Artificial bacteria, bacteria behavior, Chemotaxis and communication, Reproduction and elimination, Migration.

1. INTRODUCTION

The aggregative collection of insects or animals is known as swarm behaviour. It also term as the branch of artificial intelligence. Swarm intelligence is defined by Bonabeau as “any challenge to propose algorithms to solve problems inspired by the collective behaviour of the social insect colonies and other animal societies” [13]. The self-organization and labor division are the key components of swarm intelligence. Some advantages of Swarm intelligence such as scalability, fault tolerance, adaptation, speed, modularity, autonomy and parallelism [14]. In Recent years, nature inspired optimization technique has attracted many researchers like Particle swarm optimization [6] it based on the behaviour of bird flocking or fish schooling, ant colony optimization [4] it based on the behaviour of ants and bee algorithm based on honey bee are simulated by natural swarm organisms [5]. Although PSO and ABC are the most popular swarm algorithms for solving complex optimization problems, they present serious flaws such as premature convergence and difficulty to overcome local minima [15, 16]. Nowadays Bacterial based algorithm is mostly used to solve the real world problems like PID Controller [1], Machine learning [2] and so on. Bacterial algorithm based on foraging behavior of Escherichia coli bacteria (Passino, 2002). The main idea of this behavior is to find a maximum nutrition in a particular time. Bacterial based algorithm mainly considers the behavior of bacteria [7].

The E. Coli bacterium has a plasma membrane, cell wall, and capsule that contains the cytoplasm and nucleoid [3]. E. Coli grows, it gets long and then divides into two “daughters.” If it take sufficient food and keep at the temperature of the human gut of 37°C.E. Coli can reproduce itself and take a copy of itself in about 20 min; hence increase of a bacteria is exponential with a comparatively short time to double.
1.2 Principle:
Chemotaxis and communication are merged together for whole optimization process [1]. After long process of chemotaxis and communication model bacteria may die for lack of food or it reproduce [10,11]. In the complicated environment some bacteria may go out of boundary, for this reason in bacteria life cycle migration perform as an independent model it involves energy depletion, group diversity and chemotaxis efficiency [2]. The bacteria life cycle is shown in Fig 3.

1.3 Chemotaxis and communication model:
In this phase bacteria trying to find wealthy nutrition, if it find good nutrition it will keep on swimming in same direction otherwise it will tumble to change current direction. Chemotaxis combined with communication for whole optimization process. The important phases in chemotaxis operation is Tumbling, moving and swimming [9]. In the process of running, all flagella turn counterclockwise to form a dense propelling the cell along a helical trajectory. In this way, bacteria can swim straightly in one direction. In the case of tumbling, the flagella rotate clockwise, which pull the bacterium in different directions. Fig 4 represent the structure of chemotaxis and it directed by three elements: group information, personal previous information, and a random direction. These refer running and tumbling bacteria moves toward optimum solution.
1.5 Migration model:
In migration model, bacteria can yield more nutrition [12]. Migration of bacteria not depends upon certain probabilities it depends upon certain conditions. If the condition is satisfied bacteria would move to new random place as described below.

\[ \text{Position}_i(T) = \text{rand}.(ab - lb) + lb \]  

(4)

Where \( \text{rand} \) denotes random number between 0 and 1, \( lb \) means lower boundary and \( ub \) means upper boundary. As per optimization concept, migration model can avoid local optimum problem.

Algorithm for migration model:
Begin
Step 1: For each bacterium
Step 2: if rules is satisfied then migrate to new position by formula (4)
Step 3: else it perform chemotaxis model using formula (1) and (2)
Step 4: If terminating condition is not satisfied, then go to step 2.
End

2. Implementation of Chemotaxis and Communication:
As illustrated above, bacteria chemotaxis life time can be divided into two models: tumbling and swimming. In the process of tumbling, a stochastic direction participates into actually swimming process. Therefore, turbulent director and optimal searching director altogether influence the search orientation in tumbling. update the positions of each bacterium as 5, whereas no turbulent director acceding in swimming process to affect the bacteria swimming toward optimal as 6 formulated:

Therefore, the updating the position of the each bacterial colony as follows,

\[ \text{Position}_i(T) = \text{Position}_i(T - 1) + C(i) \]

\[ * [ f_i(G_{best} - \text{Position}_i(T - 1)) + (1 - f_i) ] \]

\[ * (P_{best_i} - \text{Position}_i(T - 1)) + turb_i \]

\[ Position_i(T) = Position_i(T - 1) + C(i) \]

\[ * [ f_i(G_{best} - \text{Position}_i(T - 1)) + (1 - f_i) ] \]

\[ * (P_{best_i} - \text{Position}_i(T - 1)) \]

(18)

Where, \( turb_i \) denotes the turbulent direction variance of the \( i^{th} \) bacterial colony, \( C(i) \) - is the chemotaxis step size of the \( i^{th} \) bacterial colony, \( f_i \in (0,1) \), \( G_{best} \) is the global best and \( P_{best} \) is the personal best of the \( i^{th} \) bacterial colony. \( Iter_{max} \) and \( Iter_j \) are the maximum iteration and current iteration respectively.
3. CONCLUSION

To enhance the global search behavior in swarm intelligent family, bacterial based algorithm shows the better result. In this paper bacterial optimization algorithm has been discussed. The bacteria are treated with agent of swarm intelligence. The communication capability is one of main aspect of group intelligence. Additionally, reproduction, migration and elimination are optimization strategies in bacterial algorithm. Many researchers prove that this algorithm improves the convergence speed and precision. Here we presented the basic behavior of bacterial colony optimization.

REFERENCES


[10] Yu-Peng Chena,b, Ying Lia,b, Gang Wanga,b,* , Yue-Feng Zhenga,b, Qian Xua,b, Jia-Hao Fanab, Yue-Ting Cuia,b, “A Novel Bacterial Foraging Optimization Algorithm For Feature Selection”, 10.1016/j.eswa.2017.04.019.


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