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Modified Search Solutions Based ABC with Mutation Algorithm for TSP

Umesh Gera**, Aparajit Shrivastava
Department of Computer Science, Shriram College of Engineering and Management, Gwalior, Madhya Pradesh, India

Abstract

Swarm intelligence systems are basically made up of simple agents' population, which are interacting locally with each other and with their surroundings. The artificial bee colony algorithm (ABC) is for aging behavior based optimization algorithm. In this paper, modified version of ABC algorithm, called as ABCM, is used. In this algorithm, two equations of original ABC algorithm are modified: First is the search equation of employed bee and second is the search equation of onlooker bee. These modified search equations greatly increase the exploration and exploitation of ABCM algorithm. Also in the ABCM algorithm, mutation operator is used after the employed bee phase of the ABCM algorithm. Proposed algorithm is implemented on travelling salesman problem and compared with the original ABC algorithm and ABC with SPV algorithm. Experimental results show that the proposed algorithm performance is better than the previous versions of ABC algorithm.

Keywords: *Artificial bee colony, ABC, mutation, ABCM, genetic algorithm, GA*

****Author for Correspondence*** E-mail: umeshgera2000@gmail.com

INTRODUCTION

Nowadays, optimization is one of the crucible problems and lots of works have been done previously to solve these problems. There are many types of optimization algorithms like GA, ABC, PSO, ACO, etc. and lots of works in these algorithms are available in the literature [1]. Karaboga defined an algorithm, called artificial bee colony (ABC) for solving numerical optimization problem [2]. This algorithm is based on the foraging behavior of honey bees. Different versions of ABC algorithm have been proposed like artificial bee colony algorithm with mutation [3], ABC with crossover, ABC with SPV [4], ABC with crossover and mutation [5, 6] and many different versions have been proposed. Dynamic division of bees into subgroup is done and the searching process is performed on these generated subgroups [7].

Karaboga defines the modified algorithm for solving real parameter optimization problems [8]. Comparative study on different evolutionary algorithms like particle swarm optimization (PSO), ABC algorithm, differential evolution (DE), ant colony algorithm (ACO), etc. and performance derived on different benchmark functions has also been done by several researchers [9, 10]. For improving the exploitation, Karaboga proposed a modified ABC algorithm based on global best solution [11]. Haijun and Qingxian proposed an enhanced artificial bee colony algorithm for function optimization [12].

In this paper, artificial bee colony algorithm with mutation operator using modified search solutions are used to increase the exploitation property of ABCM algorithm. The remainder of this paper is organized as follows. Next part describes the artificial bee colony algorithm with mutation, followed by the explanation of the proposed algorithm. Experimental results and parameter setup for result comparison are shown after that. Finally, the conclusion of the paper is presented.

ARTIFICIAL BEE COLONY ALGORITHM WITH MUTATION

One more phase in the form of mutation operator of genetic algorithm is added to original artificial bee colony algorithm [3, 5]. In standard ABC algorithm, there are only four phases that described the overall working of this algorithm, but here, one additional phase after the onlooker bee phase of ABC algorithm is added in the form of mutation operator. Now modified artificial bee colony algorithm has four phases:

- First initialization phase,
- Employed bee phase,
- Onlooker bee phase,
- Scout bee phase, and finally
- Mutation phase.

For the local search, employed bee phase is used and the mutation phase is used to find out the new search area of the solution space. With the help of mutation operator, there may be a possibility to change the local best position and the algorithm may not be trapped into local optima. In this work, the mutation phase is implemented on the probabilistic way in each iteration for searching food source during the life process of ABC optimization technique. Food sources are selected randomly from the food size to perform mutation operation. In mutation phase, if generated offspring's fitness is greater than the older one, it then replaces the older offspring's from the new one. Uniform mutation is used in this work.

In this algorithm, initial populations of food sources are generated by the following equation:

$$X_{i,j}=X\min, j+\text{rand}\ (0, 1) * (X\max, j-X\min, j) \quad (1)$$

Where, i=(1, 2, 3…SN), j=(1, 2, 3, …D). Here SN is equal to the number of food sources and D is dimension of the problem, Xmin, j and Xmax, j are the upper and lower bounds of $X_{i,j}$. To generate candidate food source position from the previous one, following equation is used:

$$Vi,=Xi,+\phi i, *(Xi, j-Xk, j) \quad (2)$$

Where k=(1, 2, 3, …SN), j=(1, 2, 3…D) are random indexes, $\phi i,j$= random number in the range [–1, 1]. Here k is different from i.

The overall algorithm is described in following steps:

- Initialization phase.
- REPEAT

i. In the memory, employed bees are placed on the food sources;
ii. Produce new population from older one after applying mutation operator;
iii. In the memory, onlooker bees are placed on the food sources;
iv. Send the scout bee to the search space for finding new food sources.

- UNTIL (requirements are not met).

PROPOSED METHODOLOGY

This section represents proposed methodology. Here ABC with mutation algorithm using modified search solutions is used to increase the exploitation property of the algorithm.
The exploration is the ability of investigating the various unknown regions in the solution space. So it is also very important in ABC algorithm. To retain the exploration, modified search equations of the employed bees are presented as follows:

$$Vi,=Xr,+\phi i, *(Xr, j-Xk, j) \quad (3)$$

Where the index r, $k$is randomly chosen from (1, 2, . . . , SN),and different from the index i. $j \in (1, 2, . . . , D)$ is a randomly chosen index. , is a random number in the range [−1, 1].

On the same way, for taking the advantage of the information of the global best solution to guide the search of the candidate solution, an enhanced equation is proposed to serve the search equation of onlooker as follows:

$$Vi,=X\text{best},+\phi i, *(X\text{best}, j-Xk, j) \quad (4)$$

Where the index $k$is a mutually exclusive integer randomly chosen from (1, 2, . . . , SN), and different from the index i. Xbest, is the jth element of the global best solution and $j\in$ (1, 2, . . . ,) is a randomly chosen index, is a random number in the range [s a ran

In this proposed work, Eq. (1) and (2) of the ABCM algorithm are replaced by the Eq. (3) and (4) respectively with the help of these modified search equations, we can increase the exploitation property of the ABCM algorithm.

EXPERIMENTAL RESULTS AND PARAMETER SETUP

This section describes the travelling salesman problem, parameter setup for the experiments and the experimental results.

Travelling Salesman Problem

Travelling salesman problem is one of the NP-complete problems which cannot be solved easily for large problems. It is defined as a problem where there are n cities and a salesman has to visit all the cities with minimum distance covered during whole path. In this problem, the distances between two cities are calculated using following formula:

$$D=\sqrt{(x1-x2)2+(y1-y2)2}$$

Parameter Setup

For every algorithm, there are some control parameters, which are used for its efficient working. Hence, there are some control parameters for bee colony with mutation algorithm also. We did an extensive literature survey and carried out our own experiments for determining the values of these control parameters. From this, we found that the values which we have taken in this experiment are standard values and they are also suitable for this experiment.

Maximum cycle number: 2500;
Number of Food Sources: 30;
Number of runs: 30;
Dimension Size: 30;
Mutation probability: 0.3.

Experimental Results

In this section, we analyze the result obtained by our algorithm. To test the efficiency of our algorithm results of proposed algorithm are compared with classical ABC algorithm and ABC with SPV algorithm results. Experiments are performed on different dimensions. Table 1 and Graph 1 show the experimental results at dimension 10. Table 2 and Graph 2 show the experimental results at dimension 20. Table 3 and Graph 3 show the experimental results at dimension 30 (Figures 1–3 and Tables 1–3).

Table 1: *Shows Results At D=10.*

Algorithms	MCN = 500	MCN = 1000	MCN = 1500	MCN = 2000
ABC	88.85	83.41	81.37	79.42
ABC with SPV	87.73	82.83	80.77	78.73
Proposed Algorithm	86.38	81.48	79.82	77.85

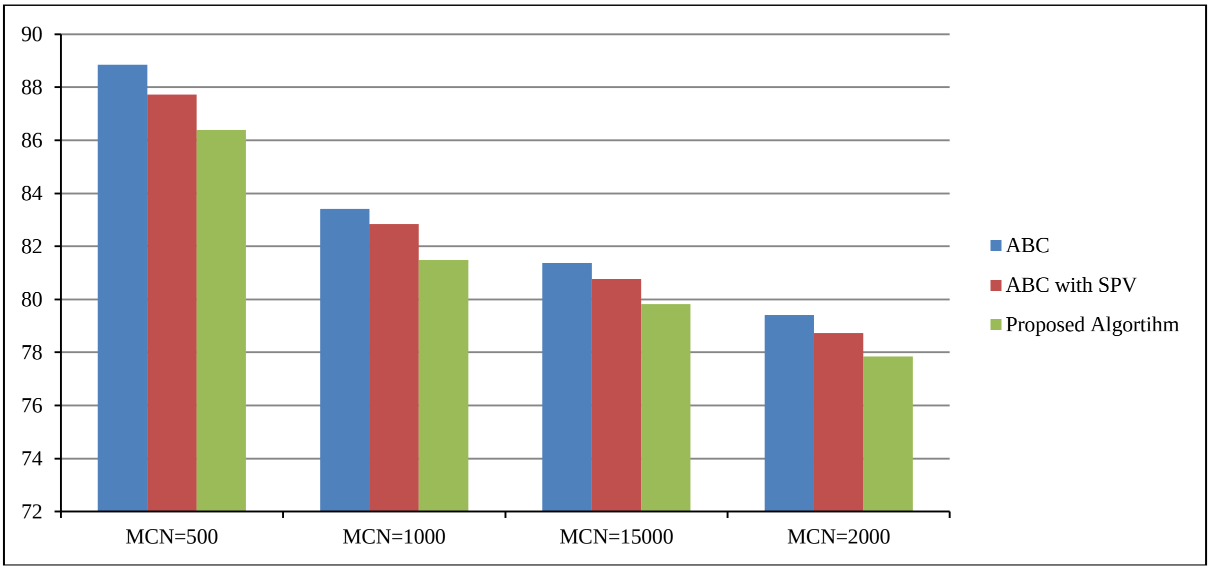

Fig. 1: *Shows the Results at D=10.*

Table 2: *Shows Results at D=20.*

Algorithms	MCN = 500	MCN = 1000	MCN = 1500	MCN = 2000
ABC	176.41	173.87	169.88	168.85
ABC with SPV	174.52	172.69	168.34	167.27
Proposed Algorithm	173.54	170.49	165.81	163.33

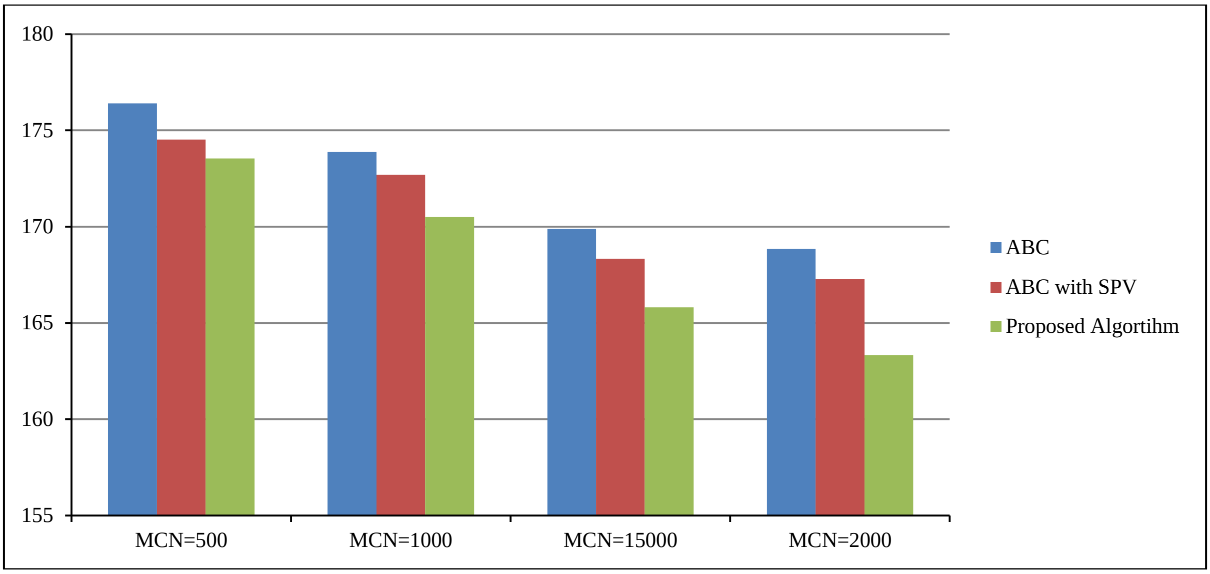

Fig. 2: *Results at D=20.*

Table 3: *Results at D=30.*

Algorithms	MCN = 500	MCN = 1000	MCN = 1500	MCN = 2000
ABC	267.42	265.28	264.55	262.44
ABC with SPV	266.10	265.81	263.47	260.23
Proposed Algorithm	264.74	263.11	261.39	259.91

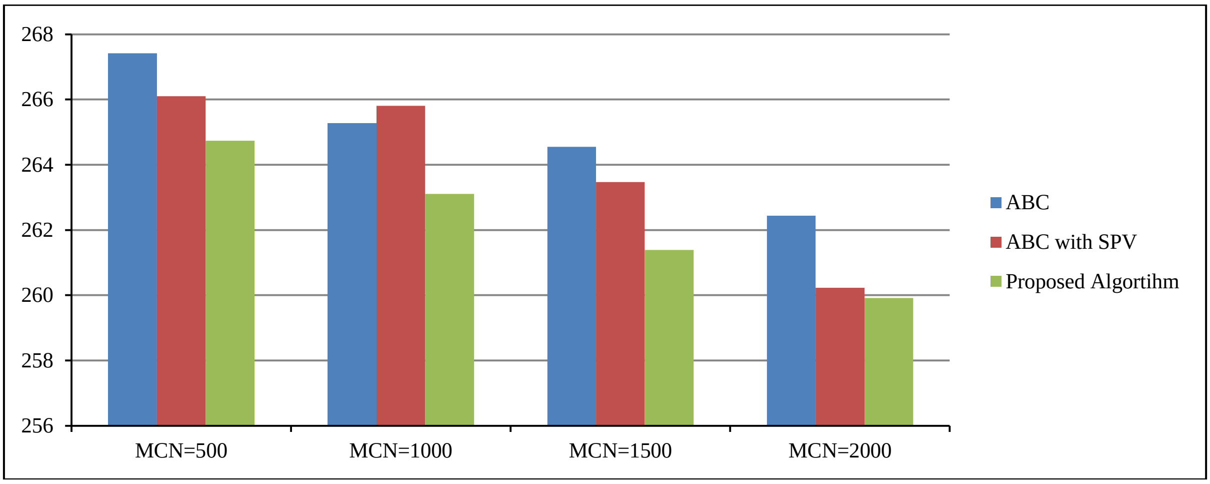

Fig. 3: *Results at D=30.*

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