Journal of Advanced Computing and Communication Technologies *(ISSN:* 2347 - 2804*)*
Volume No.2 Issue No.2, April 2014

Enhanced Artificial Bees Colony Algorithm for Travelling Salesman Problem

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ABSTRACT
This paper presents an improved algorithm for Travelling Salesman Problem using Artificial Bee Colony Algorithm. This algorithm is used to find shortest path such that a salesman visit each city exactly once. The ABC algorithm used is inspired by the collective behavior of bees to find better food sources around the hive.

Keywords
Travelling Salesman Problem (TSP),Artificial Bees Colony Algorithm, Swarm Intelligence

1. INTRODUCTION
The Travelling salesman problem (TSP) [2] is an NP hard problem devised for combinatorial optimization. It is about finding Hamiltonian path that is of minimum cost which implies that each city is visited exactly once. On its formulation from 1930, is one of the most intensively studied problems in optimization. Various optimization methods use TSP as their benchmark. TSP finds its applications in various fields such as planning, logistics and manufacturing of micro chips. Efficient solutions to such problems are required which would result in greater productivity and lesser cost. Thus importance of TSP in various fields attracts researchers to propose better solutions. In this paper swarm based algorithm is defined for solving the TSP that is capable of finding good solutions efficiently.

Section 2 describes the swarm intelligence and the previous work done. Section 3 deals with the natural bees, their foraging behavior and the core ideas of the Bees algorithm. Section 4 describes the proposed methodology for solving TSP.

2. Swarm Intelligence
Swarm based metaheuristic has motivated researches in recent times. The swarm intelligence, defined by Bonabeau, is an attempt to design algorithms which are inspired and imitates the collective behaviour of social insects while trying to achieve the solution to the problem [1]. The property of swarms to self-organise themselves that results in collective behaviour due to the local interaction among simple agents is mimicked in swarm algorithms. Another important feature of swarm is the labour division or it can be called as task allocation that is specialist individuals perform different tasks simultaneously that helps in colonies of swarms functioning efficiently.

Bee algorithm is a population-based search algorithm which is based on the foraging behaviour of honey bees. Bees communicate through waggle dance which forms basis for their foraging behaviour. The important information about the food source is conveyed through waggle dance to the bees present in the hive. The bee system, proposed by Lucic and Teodorovic (2001) [3], uses the collective intelligence property of the bee colony for finding the rich food source. The proposed method can be used for solving different problems of combinatorial type. Travelling Salesman Problem was used for testing the proposed approach. The new model using the combination of bee and fuzzy logic was proposed by Lucic and Teodorovic that is tested on vehicle routing problem. The job shop scheduling problem was solved by bee colony algorithm as proposed by Chin Soon Chong [5] (2006). The results indicated better mean, maximum percentage and more number of best solutions. The bee colony algorithm is applied to tsp and involves two parameters: fitness of the arc and distance between two cities m and n. This solution was presented by Li-Pie Wong [6] (2008). The mode of communication among the bees is the waggle dance. The scaling factor, average profitability of bee colony and bee's profitability score is used for evaluating the duration of the dance.

3. The Bees Algorithm
3.1 Honey Bees in Nature
In order to find more number of food sources, colony of honey bees is extended in multiple directions for long distances at a same time. [7, 8].The prosperity of colony is due to the deployment of its foragers to good fields. They follow the principle that flower patches with plenty amount of nectar is visited by more bees and the ones having less amount of nectars have fewer visitors [9,10].

3.2 Artificial Bee Colony Algorithm

The food foraging behaviour involving intelligence of honey bees is the main motivation for Artificial Bee Colony Algorithm. One of the most intelligent swarms existing in nature is honey bees swarm which follows collective intelligent method during the food search. The various qualities possessed by honey bee swarms are communicating of information by the bees, memorizing of the environment, storing and sharing the information and taking decisions based on the information. According to the changing environment, the updation of swarm by itself takes place. Then tasks are assigned dynamically and further movement occurs due to social learning and teaching. This behaviour of bees having intelligence forms the motivation for researchers to simulate above foraging behaviour of the bee swarm.

3.3 Analogy of Artificial Bee Colony Algorithm

The three major elements as proposed by D. Karaboga [11] are: food sources, employed and unemployed foragers. The employed bees are associated with food sources which are appropriate. The knowledge about the food sources is present with the employed bees. Employed bees are responsible for the exploitation of food sources. The employed bee changes to unemployed when the food sources become abandoned. The bees which do not have any information about the food source and searches for a food source for exploiting are unemployed foragers. The unemployed bees are classified into two types: scout bees and onlooker bees. Scout bees are those unemployed bees that search for new food sources randomly which surrounds the hive. Onlooker bees are those bees which uses the information conveyed by the waggle dance to search for new food sources for exploitation. The third element is the food source rich in nectar and present close to hive. Thus number of solutions is represented by the number of food sources in the algorithm. Further, the position of a favourable solution is represented by the location of food sources for optimization problem because the fitness cost of the solution corresponds to the nectar quality of a food source.

3.4 Phases of Artificial Bee Colony Algorithm

There are three major steps in search process [11]. These are:

- The employed bees are send to the food source and its nectar quality is calculated.
- On the basis of information form the employed bees about the food source and its nectar quality, food sources are selected by the onlooker bees. .
- Then determination of scout bees takes place and after that they are employed onto possible food sources.

At the initial stage, the bees arbitrarily select the food source location and calculate its nectar quality. The information about the food source with its nectar quality is shared by employed bees with the bees (onlooker) waiting within the hive. After this, employed bees come back to the food sources that have been found in previous cycle. Based on the old food sources, employed bee find new food sources by using its information in the neighbourhood of old food source. At last, the information shared by the employed bees at dance area is used by onlooker bees for finding food source with good nectar quality. The selection of food source and its nectar quality are directly related to each other. The more the nectar quality the more is possibility of selecting the food source. Thus onlooker bees are employed by the employed bees to the food sources having highest value for its nectar quality. Then it chooses the new food source by using the information present in her memory. When the food source becomes abandoned due to the exploitation by onlooker bees, scout bee randomly searches for new food source

4. Proposed Methodology

In our proposed model, a group of bees is created that contains active, inactive and scout bees. The number of active bees is taken to be 75% of the total number of bees while scout and inactive bees are taken to be roughly 15 % and 10% respectively. This constitutes the initialization phase. Subsequently foraging process is initiated. Bees explore and exploit the search space to find the optimal solution for the TSP. The bees are allowed to explore the search space in random during the first bee cycle since they do not have any waggle dance to follow upon. In the next phase cities data is given as an input with the number of cities that are to be visited by salesman. Then a collection of bees is created each of which has a random solution. Then the solution having least value of distance is taken to be the best solution. Further the bee optimisation is set to find the best solution. Then active bees, scout bees and inactive bees are made to do their part of work. The active bees and the scout bees observe the waggle dance. The active bee first obtains a neighbour solution relative to its current solution stored in its memory, and then determines the quality of that neighbour. If the current bee finds a better neighbour solution, then algorithm determines if the bee makes a mistake and rejects the better neighbour or if the bee accepts the better neighbour. Similarly, if the current bee did not find a better neighbour solution, the algorithm determines whether the bee makes a mistake and accepts the worse neighbour solution or does not make a mistake and rejects the neighbour. If the bee has exhausted a particular food source without finding the better neighbour solution then active bee is changed to inactive bee. A scout bee generates a random solution, checks if the random solution is better than the current solution in memory, and, if so, copies the random solution into memory. Recall that smaller quality values are better. If the scout bee has found a better solution, the algorithm checks to see if the new solution is a global best solution. An active or scout bee returns to the hive and then performs a waggle dance to inactive bees in order to convey information about the location and quality of a food source. The termination criterion for optimization loop is

the number of iterations when completed and the optimal result for TSP is given by the result so obtained.

4.1. Implementation Details

The project is developed using Java with Eclipse IDE as the development tool. It has been assumed that cities are completely connected to each other and cost of traversing city c1 to c2 is different from traversing city c2 to c1. The distance between two cities is calculated as

Distance (c1, c2) =

1.0*(label (c2)-label (c1) if city c1<city c2

1.5*(label (c2)-label (c1) if cit y c2<city c1

The implementation uses the random exploration which makes the bees to start from any random node and find the neighbours randomly.

5. Simulation Results

The simulation results obtained by applying Artificial Bees Colony to the Travelling Salesman Problem are presented in the table given below. It consists of various parameters such as number of bees, number of visits, number of cycles, and the probabilities of persuasion and mistake. In table (I), there are presented name of areas with number of cities and the optimal length achieved by applying ABC and without applying ABC.

Name of area	Number of cities	Optimal distance without using ABC	Optimal distance with using ABC
Morna	34	78	33
Hoshiyarpur	56	96.5	55
Bhangel	78	123	77
Mamura	102	234	111
Acchar	140	345.5	178

6. Conclusion and Future Scope

In this paper, an enhanced artificial bee's colony algorithm has been presented for solving TSP. The result shows that algorithm has reduced cost and enhanced performance for TSP. Neighbourhood search applied after every bee cycle has increased the quality of solution or in other words decreased the distance to be covered during TSP.As initial solution is prepared using randomisation, constructive heuristics can be applied in future to have better starting point in search of optimal solutions. Tuning of parameters in algorithm will be investigated further.

7. Acknowledgement

I would to express my greatest gratitude to the people who have supported and helped me throughout this paper. I am grateful to my teacher and my friends for their never-ending support, advice and encouragement for the paper from initial stage to the final bringing of this paper.

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