Benchmarking and Testing of Hybrid ABC and GA Using Feed Forward Neural Network for TSP

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Abstract: ***The Travelling Salesman Problem is of utmost importance in many areas like Telecommunication, Operation research, Web based Mapping techniques. The Travelling Salesman Problem strives to find the path with shortest distance traversing through each city once and returning back to the original city. Finding an optimal solution can be hard with a normal brute force technique as for an n city case there could be (n-1)! possible paths all which may not be traversed in a finite time using current computation. The aim of finding an optimal solution is to find the shortest traversing path in minimum number of iterations. This paper puts forward an efficient approach which uses a Feed Forward Neural Network to be used as a Benchmarking and a self -adaptive testing frame for a hybrid of Artificial Bee Colony and Genetic to be used for finding an optimal solution of Travelling Salesman Problem. This algorithm follows a two pronged approach of reducing the iteration for a better result and fine tuning the benchmarking and testing framework.***

Keywords: Testing Framework, Benchmarking, optimal, training, error appetite

1. Introduction

Optimization problems have always been a point of interest of the researcher. It has always been an important field of study for operation research and theoretical computers. The problems like the Shortest Path problem in which we have to find the most optimal path from source vertex to destination vertex such that the total weight of the constituent edges are minimized and the related problems like single source and single destination shortest path problems are of significant importance in the field of Web Mapping (like Google Maps where we find the most optimal driving directions between two physical locations), telecommunications, robotics and VLSI design.

The importance of optimization increases manifold when we are trying to find the most optimal solution of the problems like the Travelling Salesman problem where the time to compute the best path increases polynomially with the size of the problem

With the advent of new optimization algorithms after evaluating and understand the various process around us that occurs in nature, researcher have made a giant leap towards computing the better optimization results by better utilization of present computing capabilities. Algorithm based on nature's Swarm technique like Artificial Bee Colony algorithm and algorithm based on the nature's rule of the survival of the fittest like the Genetic Algorithm has helped us to further optimize the solution of the problem. The advent of heuristic and self-learning technique like the Neural Network method which primarily is based on how human brain perceives and learns from experience has made the solution of the problem like pattern recognition more robust

Researchers have tried to come up with the hybrid of various kinds of algorithms both of the similar and different origin to come up with the best solution for the problems. Some well-known hybrid is the usage of ABC with Genetic.

2. Previous Work

Sudarshan, Partha and Achintya in their work have explained the usage of Artificial Bee Colony Algorithm in the training of a Feed Forward Neural network [1]. They have worked on the optimization of the weight in case of Back Propagation by determining the best weights using the Bee Colony Algorithm. Youssef Bassil in his work has used a Feed Forward Neural Network with Back Propagation for the path planning of a space robot [2]. It initially uses a set of random weight and a pre-defined input and desired output to calculate the mean squared error in order to calculate the new weights and then use to find the most optimal path for a space robot. Zakir H. Ahmed in his work has emphasized on the usage of Genetic Algorithm for the solution of Travelling Salesman Problem [3]. He has advocated on the usage of Sequential Crossover Operator to generate the high quality solution to the travelling salesman problem [3]. Usage of Artificial Bee Colony algorithm in getting an optimal solution for Travelling Salesman Problem is worked on by Shailesh Pandey and Sandeep Kumar [4]. They have applied a real coded crossover to generate better off springs to get better results.

3. Problem Statement

The algorithm proposed in this work considers the cities to be traversed in a two dimensional environment with no obstacles between them. We have considered time spent in the first training of the neural network using the first set of cities in the training phase and separate from using phase.

Any further training would be done in the using phase. Initially random weights are assigned to the various connections of the Feed Forward Neural Network which gets adjusted as the time progresses. The work aims to optimize the solution of the Travelling Salesman problem in determining the most optimal path in terms of the minimal weight associated with it. Each solution will have a path (which has the sequence in with each city will be visited) along with the associated weight (in terms of the fitness value associated with it)

4. Proposed Work

The algorithm firstly initializes the environment related variables used for the creating the Neural Network. The details of each step are as follows

Step 1: Initialization Phase

In the initialization phase we initialize all the related parameters which we use in later phases of the algorithm. We initialize the error limit and the initial set of trained cities and the weight of their connection. We also initialize the number of the initial population of the bee which consist of the Employed and the Onlooker bees. The initial number of the optimal solution for the Travelling Salesman problem as defined by an initial simple brute force algorithm and is set as

No. of Initial Optimal Solution = (Initial Population Size)/2 (4.1)

Step 2: Feed Forward Neural Network Creation

In this phase we construct a Feed Forward Neural Network. The Neural Network considered in this algorithm has an Input Layer, one Hidden Layer and one Output Layer.

The transfer function for each of the hidden and output layer has been defined separately and are as follows. For Hidden layer we use the Tan sigmoid function. The mathematical formulae to calculate the value of the tan sigmoid function is as below

$$V = \text{tansig}(x) = 2/(1 + e \wedge (-2 * x)) - 1 \qquad (4.2)$$

This is mathematically similar to the tanh function having only differing at small numerical value level. However in order to get a better convergence rate of the neural network we are not very much concerned about the exact shape of the graph

For the Output layer the Linear Function is used as a Transfer function which has the following denotation. The mathematical formulae to calculate the activation function is

$$V' = \text{Linear}(x) = x \qquad (4.3)$$

This is mathematically equivalent to a straight line equation passing through the origin and denoted by y= x. The initial weight used for the connection is a random allocation which gets corrected with each iteration of Back Propagation

Step 3: Training Phase of Neural Network

In the Training phase of the Neural network, it is trained using the Back Propagation technique. We can use the technique as long as the transfer functions are derivable. We use the following steps to do a back propagation

1) We perform one cycle of the forward propagation initially using a set of 20 cities to calculate the output of each of neuron using the following formulae
2) Input at a Neuron (n) = (Input1*Weight1) + (Input2*Weight2).+(InputN*WeightN) (4.4)

   The output is calculated using the Transfer function using the following formulae:

   Output (o) = Transfer Function (n) (4.5)

   Where
   n = Total weighted input from Eq. 4.4
   Transfer Function (n) = Transfer function defined for the layer (4.2) and (4.3)

   We determine the Mean Squared error using the below formulae

   MSErr = Mean ((Actual – Desired)^2) (4.6)

   Here we are simply determining the average of the squared error
3) We then perform the back propagation starting from the output and propagating till the input node. We aim to calculate the mean squared error for each node and then readjust the connecting weights using the following formulae

   New Weight (A-B) = Old Weight (A-B) + (MSErr(B) * Output (A)) (4.7)

Where
New Weight (A-B) : Weight of connection from A to B after readjustment
Old Weight (A-B): Previous weight of the A-B connection
MSErr(B): The Mean Squared Error calculated at B using (4.6)
Output(A): Output from Node A using 4.5. This will work as an input to B.

For Hidden layer the New Weight will be calculated using the following formulae which has been successfully used by Youssef Bassil in is work
For hidden neurons:

Weight (n+1) = Weight (n) + □[ΔWeight(n-1)] + [N * Output (previous neuron) * Output (this current hidden neuron) * (1-Output (this current hidden neuron)) * Σk errork * weight kj] [2] (4.8)

4) The iteration is performed till the all the weights are adjusted successfully. Now we have a trained a Feed Forward Neural Network using Back Propagation technique. We also have one of the optimal solutions for the number of cities.

Step 4: The Employed Bee Phase

The Employed Bee phase is kick started in Step 3. A predefined number of Employed Bee usually equal to the known food source (in this case the optimal solution) are used in this process. Each Employed Bee start its journey and comes back to the dancing area with the information about the distance of the path it travelled (in analogy with the nector value of the food source).

Step 5: Calculating the Fitness Value
After the completion of the Employed Bee phase, the fitness value for each of the bee is calculated (using Eqn. 4.1). As evident, the fitness of a solution is inversely proportional to the distance travelled by the Employed Bee as we are looking for the shortest (most optimal) path

Step 6: Applying Genetic Over the Employed Bees
A Sequential Cross Over is applied on the employed bees as suggested by Zakir H Ahmed [3] to get the better off springs to be used during the OnLooker bee phase

Since the chromosomes of all the employed bees are same, two Employed Bees are randomly chosen for a Sequential Crossover [3] to produce a better off spring. The fitness of the resultant offspring is calculated using the fitness function as below

Fitness (x) = 1/ Distance Travelled (x) (4.9)

The fitness value of the off spring is compared with its parents. If there has been an improvement in the fitness value then the Parent Bees are converted to Scout Bees and they start looking for the new optimized solutions. If the fitness value does not enhance then the offspring is discarded and the crossover process is continued.

A mutation is applied to the better offspring which are the results of crossover to further enhance the Fitness of the off springs. Only the off springs whose fitness value is greater than a predefined value goes to the OnLooker Bee phase for further steps

Step 7: The OnLooker Bee Phase
The genetically enhanced offspring goes to the OnLooker bees with their path information stored in them. The probability of each of the offspring is calculated using the below formulae

$$P(i) = Fitness(i) / \sum_{n}^{y=0} Fitness(y) \qquad (4.10)$$

Where
P(i): is the Probability of Offspring i
Fitness(i): Fitness value of the offspring using (4.9)
$\sum_{n}^{y=0} Fitness(y)$: is the sum of all fitness value of the off springs

Only if the probability of an offspring is greater than or equal to a prescribed limit (calculated using fitness value of the solution coming from step 3), the OnLooker bee gather its information and goes to verify the fitness of the solution. It also looks at other possible solution which may have a better fitness value. If a better solution is found then the Offspring is converted to scout bee

Step 8: The Abandoning Phase
If the fitness of an offspring/employed bee does not enhances after a certain number of trial then they are converted into the Scout bee phase

Step 9: The Initial Pause of the ABC+Genetic
The ABC+Genetic is initially paused after a certain number of iterations. The best solution found by the hybrid is then tested using the Feed Forward neural network that we have initially trained

Step 10: The Testing Phase
This is the phase where we compare the result from step 9 with the output of using the previously trained Feed Forward Neural Network for the same number of cities (from ABC+Genetic). We then calculate the Mean Squared Error using the formulae (4.6). If the error calculated is within the predefined error appetite then we exit the algorithm

Step 11: The Re Iteration and the Re Training Phase
If the Mean Squared Error calculated in Step 10 does not fall within the predefined error limit then this denotes that the solution is not optimized and we need to do re training of the Neural Network along with additional iterations (we start from where we paused in Step 9) to ABC+Genetic. We primarily perform below two Steps

1) We will use the new number input and output (coming from ABC+GA) as a training pattern for the neural network to fine tune the weight alignment of the connections of the various nodes
2) The ABC+GA is reiterated from Step 9 to get a better solution in order to reduce the mean squared error
3) All the other phase is repeated until we reach the Exit Criteria which has been defined as per Error Appetite

5. Simulation Results

The implementation of the improved algorithm is done using MATLAB using a 2.2 GHZ processor and 1 GB RAM. The city is considered to be scattered in a 2 dimensional space. The neural network is trained for a set of 20 cities. Fig 1 shows the comparison of the performance of the proposed algorithm with only ABC+Genetic

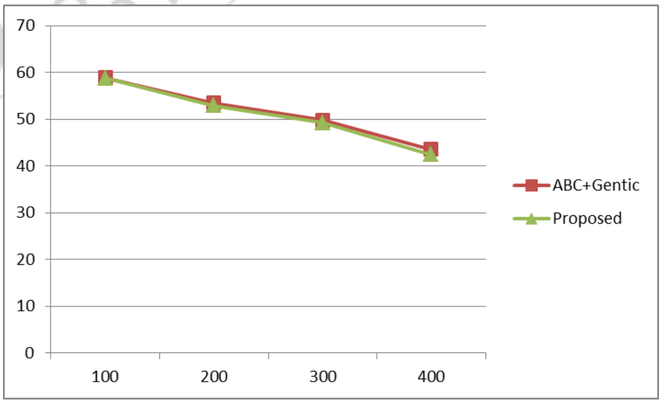

Figure 1: Performance Comparison

6. Conclusion

In this thesis, the proposed algorithm has been demonstrated and the results of detailed investigation and comparison have been presented. Moreover, when the improved algorithm is hybridized with trained neural network, the results are better and more improved. There are certain limitations found in the proposed work. Meeting these limitations is a challenge for further research. The coming subsections describe the limitations of the proposed research work and the possible future directions to be followed.

7. Future Work

The proposed testing framework helped to improve efficiency and accuracy of shortest path found by training neural network and minimizing errors found in weights but still some work is expected to be done in future. More realistic environment can be used to implement the proposed framework. This project works on two dimensional environment and the obstacles have not been considered. The future work may consider three dimensional environments. Fitness function can be improved used in Genetic Algorithm and network can be trained for large number of cities.

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