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Review Paper on Solving the Travelling Salesman Problem Using Genetic Algorithm, Ant Colony Optimization, Artificial Neural Network

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Abstract: The Traveling Salesman problem is one of the very important problems in Computer Science and Operations Research. It is used to find the minimum cost of doing a work while covering the entire area or scope of the work in concern. In this paper we will review the past work done in solving the travelling salesman problem using three different techniques- genetic algorithm, ant colony optimization and artificial neural network
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Keywords: Travelling Salesman Problem, Genetic Algorithm, Artificial Neural Network, Ant Colony Optimization.

I. INTRODUCTION

The three different techniques that will be used in this paper i.e. genetic algorithm, ant colony optimization and artificial neural network have different approaches and different parameters for solving the travelling salesman problem. Genetic algorithms (GA) are basically based on the survival of the fittest chromosome among the species which are generated by random changes in their gene-structure in the evolutionary biology. A simple GA works by generating an initial population of chromosomes randomly, which can be referred to as the gene pool and then applying three operators - reproduction, crossover and mutation to create better population for successive generations.

The base of Ant Colony Optimization (ACO) is to simulate the real behavior of ants in nature. The functioning of an ant colony provides indirect communication with the help pheromones, which ants excrete. The attractiveness of a given path depends on the quantity of pheromones. The use of more attractive route ensures that the ant excretes more pheromones on its way back and so that path is more attractive for other ants. An Artificial Neuron is a computational model inspired in the natural neurons. Natural neurons receive signals through synapses located on the dendrites or membrane of the neuron. When the signals received are strong enough, the neuron is activated and emits a signal though the axon.

A. ARTIFICIALNEURALNETWORK

The paper [1] does two significant steps solving the TSP with self-organizing maps- the original TSP is reduced to a search of a good neighborhood-preserving map and a new distance function. The work showed Wang's recurrent neural network with the "Winner Takes All" principle to find the solution of the Assignment Problem and Traveling Salesman Problem. The application of parameters with measures of matrices dispersion showed better results to both problems. The results of matrices to Assignment Problem had shown that the principle "Winner Takes all" solves problems in matrices with multiple optimal solutions, other than speed the convergence of the neural network as suggested by Wang uses only 1% of the necessary iterations of pure neural network.

Using the best combination of parameters, the average errors are only 0.71% to 100 tested matrices to Assignment Problem. These technique's solutions were considerably improved when the 2-opt technique was applied on the solutions presented by the proposed technique in this work. The data used for testing were obtained at the TSPLIB and the comparisons that were made with other heuristics showed that the technique proposed in this work achieves better results in several of the problems tested, with average errors below 16.14% to these problems. A big advantage of implementing this technique is the possibility of using the same method to solve both symmetrical and asymmetrical Traveling Salesman Problems.

This paper [2] shows a competitive study between Hopfield Neural Network and the Kohonen Neural Network. For the Hopfield neural network the work of Bose and Liang [3] was followed where a grid of n by n neurons is used where each neuron is connected to each other neuron. The weights associated with each neuron weredetermined by the energy function. The network was initialized by setting each neuron to random values between 0 and 1 to begin with. Each problem instance was solved three times to smoothen out the effect of the random initial state of the network. For the Kohonen

Neural Network, they started with a set of cities within a square unit. Euclidean distance was used to calculate the distance between two neurons. In every step, the neuron that was closest toa randomly chosen neuronwas determined. This neuron was thenmoved towards other nearby neuron. All other neurons on the ring alsomove towards that neuron, but with a diminishing intensity for the neurons with larger lateral distances between them. A heuristic first found the nearest neuron to each city. Next the cities were sorted by the place on the ring of the neurons that were closest to them. Results show that Hopfield Neural Network failed to produce result anywhere close to the best known result so far however Kohonen Neural Network produced much better results than Hopfield Neural Network but the results were still not extremely satisfying.

In this paper [4] they have implemented a unique feature which is that the net is capable of analytically inspecting down to usually unreachable level [Ritter 1992]. This is possible due to the fact that the input patterns, that are the cities of the TSP, are discrete. As a result they can show that the energy function, associated with SOFM learning, has its fully minimum in reference to the best TSP path. Their hypothesis is that we can obtain better paths for the TSP utilizing a distance function where, at the end of the process, V (W) has a value that is proportional to the simple length of the tour. The measure of the amount of optimization of the solution is the mean length obtained after the 10 iteration. The percentage wise increase of these mean lengths, when averaged over 5 sets, was around 2.49%, indicates that the averages found by this algorithm was better than the minimum found by the elastic net. These results clearly indicate that result that this algorithm gives is better than the SOFM application.

In this paper [5] they have assumed that for a given n cities, and a positive integer distance between any two cities they have tried to find the tour for the salesman that best fits a given set conditions. It is said that the Hopfield neural network is effective and it can converge to stable states much quicker, approximately in a hundred iterations. The state values are taken to be analog to allow the finite differential calculation that is used. Their results show that with the increase of number of cities the number of iterations required increases sharply and the increase is not linear. In the results it was seen that in 94% of test cases the algorithm converged, and it failed to converge in 6% of the test cases.

B. ANTCOLONYOPTIMIZATION

In this paper [6] they have shown some important works such as adapting a dynamic candidate set strategy to rapid convergence speed and proposing and implementing a dynamic updating rule for heuristic parameter based on entropy to improve the performance in solving TSP. From experimental results (Using TSP lib test cases), the proposed system is more effective than the standard ACO algorithm in terms of convergence speed and the ability to finding better solutions by 0.14% to 1.84%. This paper presents an approach for solving traveling salesman problem based on improved ant colony algorithm. An improved version of ACO algorithm based on candidate list strategy and also proposed dynamic heuristic parameter updating based on result value and mergence of local search solution has been proposed. From their experimental results, the proposed system is more effective than the ACS algorithm in terms of convergence speed and the ability to finding better solutions.

Another paper [7] adopts a system in which the new ants memorize the best-so-far solution. The proposed model was called Ants with Memory or Mant. They did some important work in this paper such as introducing the background knowledge of the TSP, AS and ACS, provide definition of the parameters used and entire environment of the experiments, explains what ants with memory are and combined them in ACS, to amend the ants with memory, then the results were generated by amended ants and compare the performance of each algorithm, dedicated to discuss the main characters of ants with memory and suggesting directions for further research. In the end, it is shown through this paper that the Mant is a very uncomplicated but interesting modernistic approach to the ACO system except the Average-Best in the table the statistical comparison told us that the probabilistic Mant has surpassed original ant in ACS at speed and quality while searching for the optimum solution. It has been shown to compare favourably with ACS algorithm, and its amelioration model probabilistic Mant got inspiring performance in ACS. However, competition on the TSP is very tough, and a utilization of best-so-far tour information which converge these solutions to a near-optimum seems to be a useful strategy. Further work for better performance of probabilistic Mant on the Dynamic TSP is still going on.

This paper [8] does two importance things, firstly well Distribution Strategy of Initial Ants - the local heuristic controlled by visibility, encourages them to choose cities which are closer. In ACO algorithm, the heuristic information is very important for getting good tours in the initial search stages. The main contribution of this paper is a study of the avoidance of stagnation behaviour and premature convergence by using distribution strategy of initial ants and dynamic heuristic parameter updating based on entropy. This paper presents an approach for solving multiple traveling salesman problem based on ant colony algorithm. ACO is a promising optimization technique for solving complex combinatorial optimization problems like the MTSP. The main contribution of this paper is a study of the avoidance of stagnation behaviour and premature convergence by utilizing distribution strategy of ants initially and by renewing the dynamic heuristic parameter based on entropy. Then emergence of local search solution is provided. Comparing the performances showed that the proposed system get improved performance when compared to other ACO algorithms.

This paper [9] transforms three behaviours of real ants into artificial ants: (i) the preference for paths according to level of pheromone, (ii) the higher rate of growth of pheromone on the shorter paths, and (iii) the trail mediated communication between the ants. Other than these the artificial ants were given some extra capabilities which are well suited for the TSP problem: artificial ants can determine how far away cities are, and they are also imparted memory to remember the already visited cities. Pheromone trail is changed both locally and globally. Global updating is for marking edges that belong to shorter tours. After completing their tour the ants deposit pheromones on the best tour. Results show that ACS finds results which are on par, and often better than, those found by the some other methods and, the best solutions found were the local optima with respect to the 3-opt. For these runs they implemented a slightly modified version of ACS which makes use of a more advanced data structure known as candidate list, a data structure which is generally used when solving large TSP problems.

C. GENETIC ALGORITHM

In this paper [10] Roulette Wheel Selection (RWS) operator with heuristic crossover and inversion mutation probabilities has been used to solve well known optimization problem Traveling Salesmen Problem. The fitness function was chosen to be the inverse of the distance between the pair nodes. They compared the results of RWS with another selection method Stochastic Universal Selection (SUS). All the computation were performed on a Pentium processor with minimum 512 MB RAM. The program was written in the C programming language.

They tested RWS & SUS method for different crossover method. It was performed on six bench mark problem instances which are taken from the TSPLIB. Crossover probability was chosen to be 0.9 while the mutation probability as chosen as 0.1. Results showed that SUS gives a better result for small number of cities and converges faster as compared to RWS. But as number of city get large, RWS gives better results than SUS.

Solving the travelling salesman problem using the genetic algorithm in this paper [11], Survivor Selection operator with Sequential Constructive crossover (SCX) and exchange mutation probabilities has been used to solve well known optimization problem Traveling Salesmen Problem (TSP). The efficiency of the SCX is compared against some existing crossover operators namely, edge recombination crossover (ERX) and generalized N-point crossover (GNX) for some benchmark TSPLIB instances. All the computations were encoded in Visual C++ on a Pentium 4 personal computer with speed 3 GHz and 448 MB RAM. The population size was 200, probability of crossover is 1.0 (i.e., 100%), probability of mutation is 0.01 (i.e., 1%). Results show that ERX is found to be better for small population size but as size of the problem increases GNX is found to be better than ERX. While overall, SCX was found to be better than both ERX and GNX.

In this paper [12], a number of crossover operators are tested. Standard results from TSPLIB are known beforehand and then the results with different crossover operators are compared. Firstly partially matched crossover (PMX) with no mutation operator is considered and is found to give results much higher than expected. Then order crossover was taken into consideration and it was found to better than PMX but still the results were on a higher side and not satisfactory. The matrix crossover method with inversion mutation was found to give much better results than boththe previous methods. The results were found to be less than 2% above the best know results. The experiment was performed on different population sizes varying from 30 to 318.

In the next paper [13] the selection method used is the Partially Mapped Crossover (PMX)which produces quality results at a convergence rate which is faster by a factor of 3-5.The mutation operator used in this paper selects two random positions of a selected chromosome and reverses their relative position to produce new individuals and if the fitness is more than the existing chromosome then the previous chromosome is discarded and the new one is kept. They implemented their algorithm as C program and the data for their test was taken from TSPLIB. The crossover probability was set to 0.15 and mutation probability was set to 0.07 and the chromosome pool size was set to 1000. The termination criteria was given to be a successive run of a number of iterations (max. number of generation/3) when the fitness of the best pool of chromosome remains unchanged. Results showed that this method produces results 1%-15% higher than the best known result so far which can be considered as a good result and also it converges faster.

CONCLUSION&FUTUREWORK

The system of new ants with memory seems to produce the best-so-far solution. They do some important work in this paper such as introduce the background knowledge of the TSP, AS and ACS, provide definition of the parameters and environment of the experiments, explain what ants with memory are and simulated them in ACS, and we will be amending the ants with memory in our algorithm, similar to what has been done in this paper with some modifications that might show the results which seems to be nearing to the optimization result of the experiments and compare the performance of each algorithm, dedicated to discuss the main characters of ants with memory and suggesting directions for further research.
Also the results produced by the technique of genetic algorithm which uses the sequential constructive crossover for the production of new population are very satisfying. They presented a comparative study between sequential constructive crossover (SCX), edge recombination crossover (ERX) and generalized N-point crossover (GNX) for some benchmark TSPLIB instances as the SCX produces results nearing to the optimization result as the population size increases. However we will

Crossover Operator as in other experiments it was seen that using the Matrix Crossover Operator produced results closer to the best known results.

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