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Particle Swarm Optimization to Solve Multiple Traveling Salesman Problem

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Abstract *In this paper, we have proposed a new genetic ant colony optimization based algorithm for multiple Travelling Salesmen Problem (mTSP). The proposed algorithm has been developed a hybrid algorithm with some properties of GA and some properties of PCO. Each salesman selects his/her route using PCO and the routes of different salesmen (to construct a complete solution) are controlled by the GA. ACO special feature namely 'refinement'. To show the effectiveness of the algorithm we use some benchmark instances and compare the results with other existing algorithms. From the obtained results, it can be concluded that the newly added features enhance the performance efficiency of the algorithm*.

Key Words: TSP, STSP. PSO ,MTSP

I. INTRODUCTION

Traveling salesman problem (TSP) means to find the shortest path between the given numbers of cities, but the condition is to visit each city only once and return back to the initial city. In TSP, salesman travels N cities and come back to the starting city with the minimal cost. The first attempt of the traveling salesman problem was done by Euler in 1759 whose problem was to traverse a knight on a chess board exactly once. In 1832, German salesman BF Voigt wrote a book[1] on the traveling salesman problem. This book suggested to visit maximum locations without visiting twice is the main aspect of scheduling the tour but not mention this by name TSP. The beginning of mathematically concept of TSP was not exactly known but an estimate of around 1931 it was started.

The following representation of the symmetric traveling salesman problem mathematically is:

Given an weighted graph G = (V, E)
In which the weight cij of edge is between node i and node j is non-negative value, to find the minimum total cost among the tour of all nodes.

TSP is an complete, weighted graph of n nodes, to find the least weight Hamiltonian cycle, that cycle visits every node once.

- Though this problem is easy enough to explain, it is very difficult to solve.
- Finding all the Hamiltonian cycles[2] of a graph takes exponential time. Therefore, TSP is in the class NP.
- One of the first TSP papers was published in the 1920s.

Applications

The TSP naturally arises as a subproblem in many transportation and logistics applications. Scheduling of a machine to drill holes in a circuit board or other object. In this case the holes to be drilled are the cities, and the cost of travel is the time it takes to move the drill head from one hole to the next.
The travelling salesman problem can be classified as Symmetric Traveling salesman problem (STSP), Asymmetric Travelling Salesman Problem (ATSP), and Multi Travelling Salesman Problem (MTSP).

(1)STSP: In STSP, the distance[4] between two cities is same in both directions which mean this will result in an undirected graph.
(2)ATSP: In ATSP, the distance between two cities is different in both directions. It is a directed graph.
(3)MTSP: In a given set of nodes, let there be 'm' salesmen located at a single depot node. The remaining nodes (cities) are intermediate nodes which are yet to be visited. Then, the MTSP finds the tours for all 'm' salesmen, who all start and finish at the place, such that each intermediate node (city) is visited exactly once and the total cost of visiting all nodes is minimized.

II.METHODS TO SOLVE TSP

One procedure that would definitely find the optimal solution of any TSP is the application of comprehensive enumeration and evaluation. This procedure consists of traversing all possible tours and evaluating their corresponding tour length.[7] The tour with the minimum length is selected as the best, which is to be optimal. If we could recognize and evaluate one tour per nanosecond (or one billion tours per second), it would require nearly ten million years (number of possible tours = 3.2×1023) to evaluate all of the tours in a 25-city TSP."

Obviously there is a strong requirement of an algorithm that will give us a solution in a shorter amount of time. There is no identified algorithm that will solve it in polynomial time because TSP is NP-hard. In order to get a good answer in a shorter time , we have to give up optimality. There are many algorithms that have been used for the traveling salesman problem. Few of them are given below:

3.1 Exact Solvers:-

There are two groups of exact solvers. First group solves relaxations of the TSP Linear Programming formulation and uses methods like Cutting Plane, Interior Point, Branch-and Bound and Branch-and-Cut. Second group uses Dynamic Programming. The main characteristic of both the groups is to find optimal solutions in a minimum running time and space requirements.

3.1.1 Branch and Bound

All the feasible solutions are perfectly specified by the Branch and Bound method, using calculations where the integer constraints of the problems are relaxed.[4] In other words the branch and bound strategy divides a problem into a number of sub-problems. This system solves a series of sub-problems each of which may have several possible solutions and where the solution which have been chosen for one can affect the possible solutions of later .We avoid the complete calculation of all partial trees and first try to find a practical solution .The value of that solution is set as an upper bound for optimum. If a new cheaper solution is found, its value is used as the new upper bound. This method is suitable for 40 to 60 nodes (cities).

3.1.2 The Cutting Plane

The groundbreaking work of Dant zig, Fulkerson, and Johnson [23] on the traveling salesman problem introduced the cutting plane method, which can be used to attack any problem minimize T S; (1)∈x subject to x where S is a finite subset of some Euclidean space IRm , provided that an efficient algorithm to recognize points of S is available. This method is iterative; each of its iterations begins with a linear programming relaxation of (1), meaning a problem minimize T x subject to Ax ≤ b; (2) where the polyhedron P defined as {x : Ax ≤ bg }contains S and is bounded. Since P is bounded, we can find an optimal solution x* of (2) which is an extreme point of P. If x* belongs to S, then it constitutes an optimal solution of (1); otherwise, some linear inequality separates x* from S in the sense of being satisfied by all the points in S and violated by x*; such an inequality is called a cutting plane or simply a cut.

III. Related Work

Shi et.al (2007):- In this paper particle swarm optimization (PSO)-based algorithm is used for solving the traveling salesman problem (TSP). To speed up the convergence speed, vague search strategy and a crossover eliminated technique is used. An PSO-based algorithm is proposed and applied to solve the generalized traveling salesman problem by employing the generalized chromosome. To accelerate the convergence two local search techniques are involved in it. To the best of our knowledge, it is the first time that the PSO-based algorithm has been used to solve the GTSP problems. Some benchmark problems are used to examine the effectiveness of the proposed algorithms. Numerical results show that the proposed algorithms are effective. It has also been shown that the proposed algorithms can solve larger size problems than those solved using the existing algorithms.

Zhang and Xiong (2008):- This paper proposed an improved PSO algorithm based on the concepts of Adjustment Operator and Adjustment Sequence. For solving traveling salesman problem, the experimental results show the effectiveness and efficiency of the proposed method. In the IPSO algorithm, the order of Adjustment Operator is one of the key factors, which decided whether the next iterative solutions are good or bad, and constringe the best solution quickly or not. How can aptly resolve the problem of each part's (includes individual's cooperation) influence to individuals is the key to solving TSP quickly and efficiently. In addition, how to set the different parameters to improve the algorithm for solve more nodes TSP effectively, all these problems deserve further study

Bifan Li, Lipo Wang, and Wu Song (2008):- In this paper, new model of Ant Colony Optimization (ACO) probabilistic Mant to solve the traveling salesman problem (TSP) by introducing ants with memory into the Ant Colony System (ACS). In the new ant system, the ants can remember and make use of the best-so-far solution, so that the algorithm is able to converge into at least a near-optimum solution quickly. Its amelioration model probabilistic Mant got inspiring performance in ACS.We have tested the algorithm in 3 representational TSP instances and compared the results with the original ACS algorithm. According to the result we make amelioration to the new ant model and test it again. The simulations show that the amended ants with memory improve the converge speed and can find better solutions compared to the original ants

Marinakis and Marinaki (2010):- In this paper, a new hybrid algorithmic nature inspired approach , namely the HybMSPSO algorithm, based on Particle Swarm Optimization (PSO), Greedy Randomized Adaptive Search Procedure (GRASP) and Expanding Neighborhood Search (ENS) Strategy is proposed for the solution of the Probabilistic Traveling Salesman Problem (PTSP). The proposed algorithm is tested on numerous benchmark problems from TSPLIB with very satisfactory results. Comparisons with the classic GRASP algorithm, the classic PSO and with a Tabu Search algorithm are also presented. Also, a comparison is performed with the results of a number of implementations of the Ant Colony Optimization algorithm from the literature and in 13 out of 20 cases the proposed algorithm gives a new best solution

Lo´pez-Iba´n˜ez and Blum (2010):- In this paper, we have proposed a Beam-ACO approach for the travelling salesman problem with time windows (TSPTW) for minimizing the travel cost. Beam-ACO is a hybrid between ant colony optimization and beam search that, in general, relies heavily on bounding information that is accurate and computationally inexpensive. This work uses stochastic sampling as a useful alternative. We also incorporated an effective local search procedure to further improve the results. An extensive experimental evaluation on seven benchmark sets from the literature shows that the proposed Beam-ACO algorithm is currently a state- of-the-art technique for the travelling salesman problem with time windows when travel-cost optimization is concerned.

Mavrovouniotis and Yang (2010):- In this paper, we investigate a hybridized ACO with local search (LS), called Memetic ACO(M-ACO) algorithm, which is based on the population based ACO (P-ACO) framework and an adaptive inverover operator, to solve the DTSP. The adaptive LS operator is used to further improve the quality of the solution obtained by the P-ACO algorithm with its strong exploitation. Moreover, to address premature convergence, we introduce random immigrants to the population of M-ACO when identical ants are stored.The simulation experiments on a series of dynamic environments generated from a set of benchmark TSP instances show that LS is beneficial for ACO algorithms when applied on the DTSP, since it achieves better performance and robustness than other traditional ACO and P-ACO algorithms..

IV. Purposed Work

We propose a genetic algorithm based on a novel multi-chromosome representation for mTSP, which is similar to the representation used for vehicle scheduling in Tavares et al. (2003). However, the crossover operators suggested by Tavares et al. may produce infeasible children, thus, additional improvement steps have to be performed. In contrast, our operators always generate feasible solutions, i.e. further correction is not necessary. Therefore, in the following we will present a short description of the used representation, and the description of novel crossover operators will receive the prime focus.

The improvement of original FOA To avoid the above problems, we should make some improvements on the original FOA. The improvement idea of this original FOA is that we do not use the reciprocal of distance as smell concentration decision value, but grasp the essence of the FOA. And regard the smell search stage of fruit flies as the random disperse phase of search populations, then the visual search phase is the time when the fruit fly population gather to the best location. In the search process, fruit flies constantly adjust their own positions according to the experience of individual and swarm. By doing like this, it can expand the search space of solution, and prevent the premature convergence and prematurity. At the same time, it can also improve the convergence speed of the algorithm. Then, based on the search model of solution, analyze the optimization mechanism of the original FOA, and propose the working steps and framework of IFOA for TSP. The working steps are showed in Fig.

The details of the working steps will be introduced in the following subsections.

1) Coding and initialization

First of all'we need use a proper way to code this problem. In this article, we use an integer permutation represent the route of TSP. Take a TSP with 12 cities as example. Integer permutation [8,2,3,1,9,5,11,6,12,10,7,4] stands for a possible traversal route. This means that individual fruit fly start from the city8, and goes through 2,3,...,4 in turn, then goes back to the city8 finally.
Secondly, we will initialize parameters, the number of iterative evolution, number of individual fruit fly, the location of the particle and so on. In this paper, IFOA uses the random initialization method to initialize population.

2) Smell search stage

In this stage, the fruit flies use the sense of smell to search the food, find the best smell density of the individual fruit fly by calculating and comparing the fitness.

3) Local visual search phase

In this stage, the fruit flies fly to the nearest and the best smell density location through visual sense. In this process, it is easy to fall into local optimal solution The genetic algorithm produce better solution in tsp problem

Algorithm 1.

Compute an initial population of N random individuals
Apply local search on these individuals
While the number of iterations is lower than N1 and an improvement has occurred since less than N_2 iterations do
for i=1 to k do
Choose 2 individuals randomly
Construct 2 children with crossover
Apply local search on both children
Add children to the population
end for
Keep the N best individuals in the population
Apply mutation with a probability to every individual of the population
end while

Pseudo Code

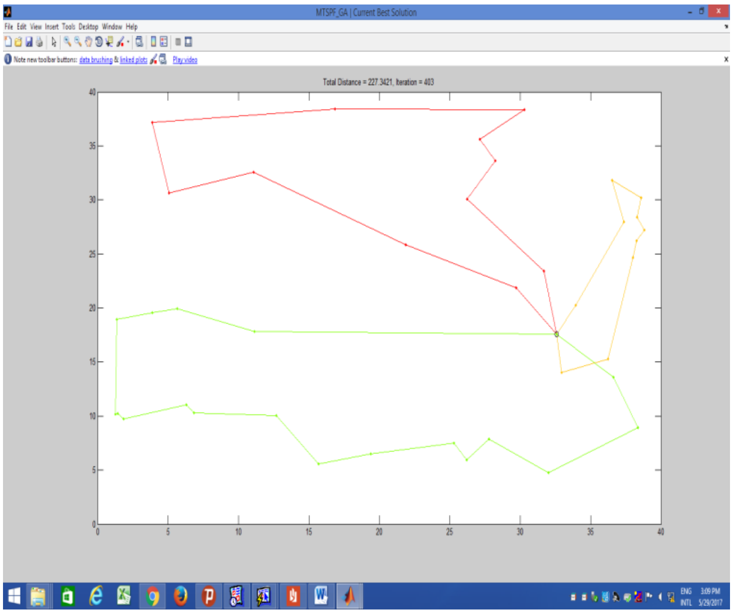
```
procedure thread;
lock;
while lastrow < M do
my_row := lastrow;
lastrow++;
unlock; for i:=1 to P
do C(my_row,i) := 0;
 for j:=1 to N do
 C(my_row,i) := C(my_row,i)+A(my_row,j) . B(j,i);
lock; unlock;
```

In the same manner TSP-PSO algorithm can be implemented in multi-core environment on a multithreaded base to improve the performance at certain level. If the threads are implemented on a low communication environment then results many not be good, where as if the threads are implemented in a more communication environment, the overall performance will be improved for larger values of vertices (cities). Wide application in real practice such as Path. Routing and Distribution problems, it has attracted researchers of various domains to work for its better solutions. Those traditional algorithms such as Cupidity Algorithm, Dynamic Programming Algorithm, are all facing the same obstacle, which is when the problem scale of larger values of N.

V. Simulation Result

To analyze the new representation, a GA using this multi chromosomal technique was developed in MATLAB, and the new method was compared with the best known one-chromosomal approach (the two-part chromosome technique). To make a fair comparison, we have developed two different algorithm, both of them are based on the implementation available on MATLAB Central.1 The complete actual code of the algorithms is available on our website. The algorithms use two matrices as inputs, the set of coordinates of the locations (for visualization) and the distance matrix which contains the traveling distances between any two cities (in kilometers or in minutes).Of course, genetic parameters have to be specified also, like population size, number of iterations, or the constraints for the novella algorithm .First, the initial population is generated which consist of individuals with randomly permuted genes. In both algorithms, the fitness function simply computes the sum of overall route length (or duration) of each salesman inside an individual.. These additional parameters will be considered in our new GA, which will be discussed in Section 5. The selection is tournament selection, where in our case the tournament size (i.e. the number of individuals who compete for survival) is 8. The individual with the smallest fitness value wins the tournament, thus it will be selected for generating new individuals, and this member will be transferred into the new population without any modification.

The experiment was carried out using the constructed ant colony system. The search graph had 50 vertices (cities). The length of the optimal route in this case is 426 units while using the ant colony system, the route amounts to 430.4 units. Both routes are presented in Figures 1 and 25



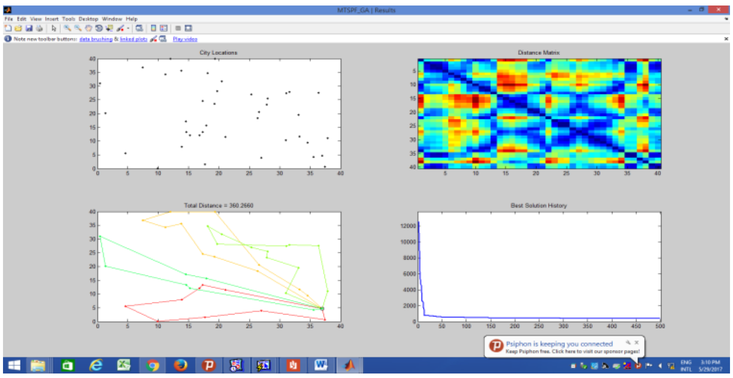
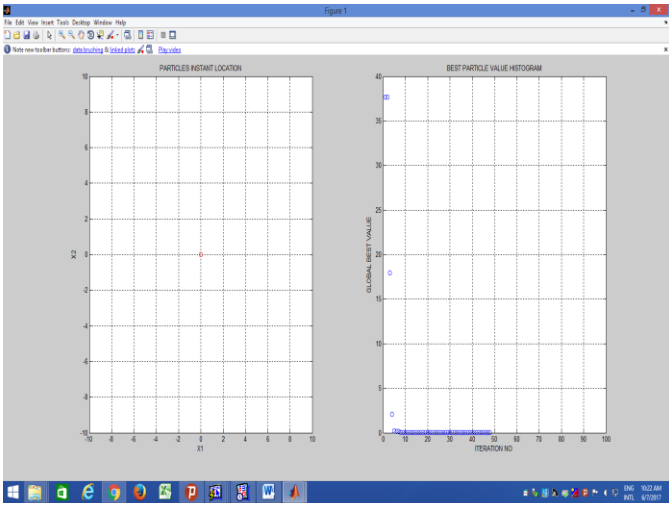


Fig 5.1 : MTSP based on Genetic Algorithm



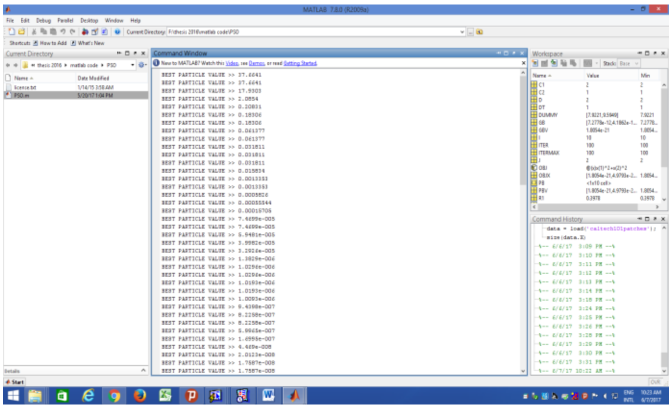


Fig 5.2 : MTSP based on Genetic Algorithm

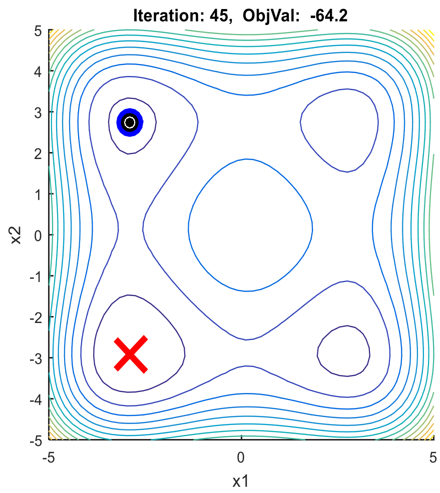


Fig 5.3 Initial position and target position

Starting point is described in blue and end point s describes in red.

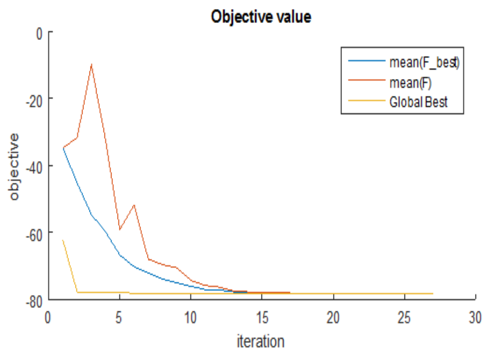


Fig 5.34 Objective value

Because we have to minimize the energy of overall system, the objective function must be decreased as number of iterations started to increase. Both mean, mean best and mean global best values decreases and iteration gets improved.

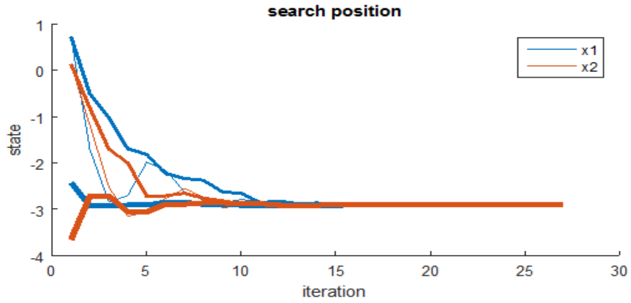


Fig 5.5 Search position

Search position indicates exact position of start. It can be seen that in less than 10 iterations, target position has been achieved.

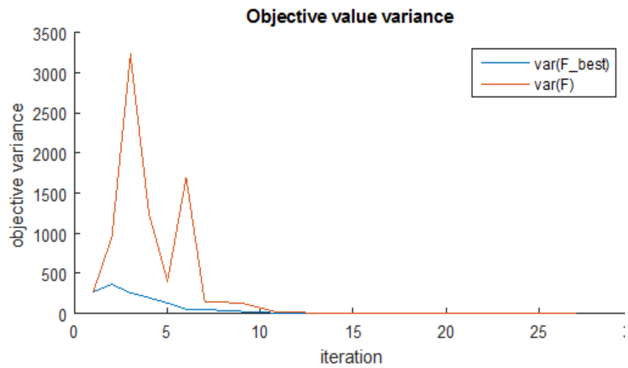


Fig 5.6 Objective Value variance

VI. Conclusion and Future Scope

In this paper proposed two improved genetic algorithms based on clustering to find the best results of TSPs, i.e.. The simulation experiments results show that the improved PCO is effective for solving traveling salesman problem, which not only accelerates the convergence velocity, but also inhibits the premature stagnation in the convergence process. The results for TSP problem show that the proposed method can converge to the global optimal solution quickly and accelerate the convergence rate. The simulation results verify the effectiveness of the proposed algorithm.

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