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Two-Level Genetic Algorithm for Clustered Traveling Salesman Problem with Application in Large-Scale TSPs

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Abstract: Solving NP hard problem like Travelling Salesman Problem (TSP) is a major challenge even though many techniques are available. Different types of Genetic algorithms have introduced by the Researchers to better improve the performance of TSP. Traveling Salesman Problem (TSP) is coded in genetic form. A software system is proposed to determine the optimum route for a Traveling Salesman Problem using Genetic Algorithm technique. The Clustered Genetic algorithm was introduced for implementing TSP. The clustered traveling salesman problem (CTSP) seeks to compute the shortest Hamiltonian tour that visits all the vertices, in which the vertices of each cluster are visited consecutively. A two-level genetic algorithm (TLGA) was developed for the problem, which favours neither intra-cluster paths nor inter-cluster paths, thus realized integrated evolutionary optimization for both levels of the CTSP. Clustering TLGA for large TSPs is continuous and discrete problems.

Keywords: Genetic algorithm, Travelling Salesman Problem (TSP), Clustered Travelling Salesman Problem (CTSP), Hamilton cycle.

I. INTRODUCTION

The travelling Salesman Problem starts from first node visiting all the nodes each node exactly once and reaching at the destination[3]. It is mentioned as one of the main optimization problems and its solving plays an important role in other problems solutions. In this problem, some cities should be travelled by a salesman in the shortest way. Finding the shortest way between cities or the shortest Hamiltonian cycle in graph is the goal of this problem[2]. The clustered traveling salesman problem (CTSP) searches for computing the shortest Hamiltonian path that visits all the vertices, in which the vertices of each cluster are visited consecutively. There are many applications of the CTSP. The CTSP is NP-hard problem, and the traveling salesman problem (TSP) can be viewed as a special case of the CTSP in which there is only one cluster or each cluster has only one vertex. There are several variants of the problem depending on whether the start and end vertices of a cluster have been specified.

1. Genetic Algorithm :

GTSP is defined on a weighted graph in which nodes have been pre-grouped into m mutually exclusive and exhaustive node sets or clusters. The GTSP is the problem of finding a minimum cost cycle which includes exactly one node from each cluster. GTSP can be reduced to TSP if single node present in each of the cluster. Being a generalization of TSP, GTSP is also NP-Hard problem. GTSP is a useful model for problems involving two simultaneous decisions of selection and sequence. Here I am dealing with the symmetric GTSP[3].

Genetic algorithm (GA) is one of the most commonly used optimization techniques to solve combinatorial optimization problems like the TSP. GA is an evolutionary technique that use crossover and mutation operator to solve optimization problem using a survival of the fittest idea. This technique does not ensure an optimal solution, however it gives good approximation in a reasonable amount of time. Therefore GA is a well studied for NP-Hard problems like GTSP

Genetic Algorithms are heuristic search algorithms. GA represents an intellegent method of random search within defined search area to solve the problem. GA is a computational analogy system and it belong to the larger class of evolutionary algorithms (EA), which generate solutions to optimization problems using techniques such as mutation, selection, and crossover.

Advantages

1. It can solve every optimization problem which can be described with the chromosome encoding.
2. It solves problems with multiple solutions.
3. Since the genetic algorithm execution technique is not dependent on the error surface, we can solve multi-dimensional, non-differential, non-continuous, and even non-parametrical problems.

Disadvantages:

1. Certain optimization problems (they are called variant problems) cannot be solved by means of genetic algorithms. This occurs due to poorly known fitness functions which generate bad chromosome blocks in spite of the fact that only good chromosome blocks cross-over.
2. There is no absolute assurance that a genetic algorithm will find a global optimum. It happens very often when the populations have a lot of subjects.

2. Two Level Genetic Algorithm

The proposed a two-level Genetic Algorithm for TSP is a hierarchical algorithm that uses inter-cluster paths. It specify the shortest inter-cluster paths connecting every cluster and the start and end vertices for each cluster are then specified. The Christofides' algorithm is used to find the shortest Hamilton path for each cluster and then the whole tour is formed by combining all the shortest path.

This paper describes a two-level genetic algorithm (TLGA) for the CTSP that favours neither of the two levels of paths, thus avoiding the disadvantages of both algorithms. The general idea is to find the shortest Hamiltonian cycle for each cluster, to delete a selected edge for each cycle to form an intra-cluster path, and then to connect all the intra-cluster paths in a certain sequence to form a whole tour.

3. Two level genetic algorithm for clustered TSP

The clustering method can be used to convert a large scale TSP into CTSP which can be solved by two level genetic algorithms. The clustering method can be used to convert a large-scale TSP into a CTSP which can then be solved by the TLGA. Test results demonstrate that the clustering TLGA algorithm for large-scale TSPs is more effective and efficient than the classical genetic algorithm. The increase in computing time of clustering TLGA is almost proportioned to the problem size.

3.1 Lower level genetic algorithm

In the lower level, a genetic algorithm (GA) is used to find the shortest Hamiltonian cycle rather than the shortest Hamiltonian path for each cluster. In the higher level, a modified genetic algorithm is designed to determine which edge will be deleted from the shortest Hamiltonian cycle for each cluster, and the visiting sequence of all the clusters with the objective of shortest traveling tour for the whole problem. Since the shortest Hamiltonian cycle rather than the shortest Hamiltonian path is formed in the lower level, it leaves open the question of choosing the edge to be deleted.

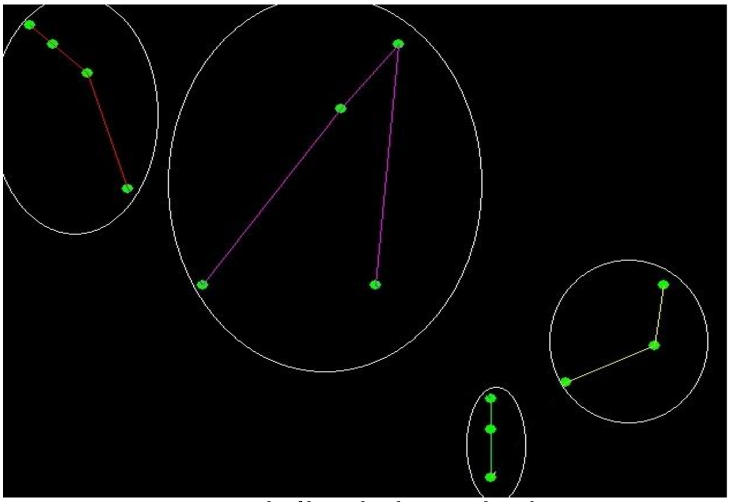


Fig 1: Result of lower level genetic algorithm

3.2 Higher level genetic algorithm

The higher level algorithm has the freedom to choose the edge to be deleted for each cluster while searching for the shortest whole tour. The clustering method can be used to convert a large-scale TSP into a CTSP which can then be solved by the TLGA. Test results demonstrate that the clustering TLGA algorithm for large-scale TSPs is more effective and efficient than the classical genetic algorithm. The increase in computing time of clustering TLGA is almost proportioned to the problem size.

4. Usage of cluster in our project –

Cluster is group of similar type of objects or things that occurs closely together. In cluster formation,the large set of data is divided into small data set. Clustering is a task of grouping a set of objects in such a way that objects in the same group are more similar to each other.

Travelling salesman problem is expanded to include the situation where group of cities must be visited continuously in an optimal, unspecified order. This project uses TSP concept for large scale applications. For large applications, it is difficult to find the optimal path. Clustering concept helps to find shortest and optimal path by dividing large application set into small data sets.

5. K means Algorithm :

K means clustering is an effective algorithm to extract a given number of clusters of patterns from training set.

K means is the one of the best method among all partitioning based clustering methods. It classifies a given set of n data objects in k clusters where k is the number of desired clusters. A center is defined for each cluster. Clusters are formed in such a way that the center of cluster is nearest to data objects.[1]

5.1 Algorithm

Input :

'k' is the number of clusters to be formed.

'n' is no of objects.

Output :

A set of k clusters based on given similarity function.

Steps:

1. Arbitrarily choose k objects as initial cluster center.
2. Repeat :
    - Reassign each object to the cluster to which the object is the most similar; based on given similarity function.
    - Update the cluster means i.e. calculate the mean value of the object for each cluster.
3. Until no change.

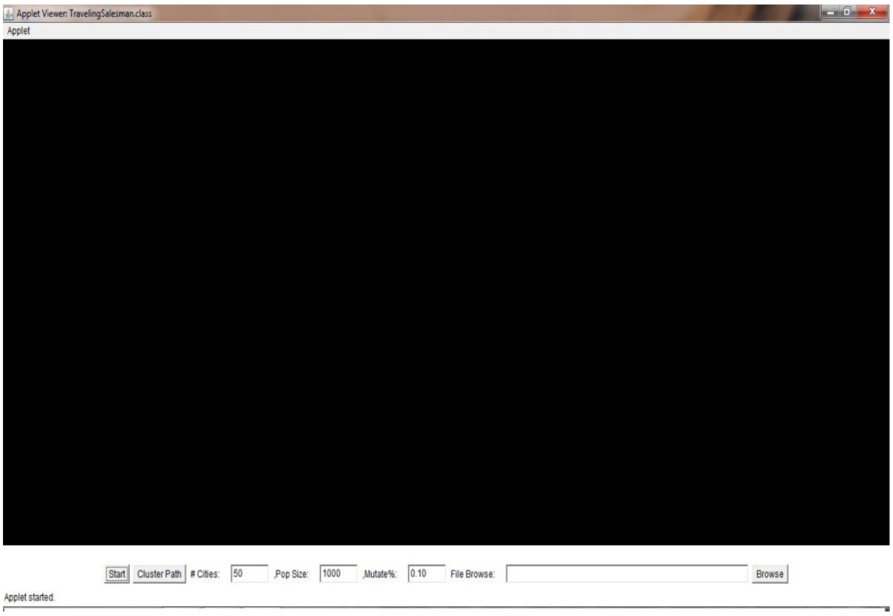
5.2Formula for K means

mEuDt = Math.sqrt(Math.pow((mX - mCluster.getCentroid().getCx()), 2) + Math.pow((mY - mCluster.getCentroid().getCy()), 2));

This formula is used for calculating the Euclidian distance between data sets.

II. IMPLEMENTATION

The applets are used for designing a start page. Applet is a special type of program that is embedded in the webpage to generate the dynamic content. It runs inside the browser and works at client side. When an applet is loaded, it undergoes through series of states, init(),Start(), paint(), stop(),destroy().



Start button:

When we click on start button,it gives the final optimal path as result of our project.

Clusterpath button:

It shows the cluster formation which is the output of lower level.

Cities:

Cities can be defined as total number of nodes that we have taken as input.

Population size:

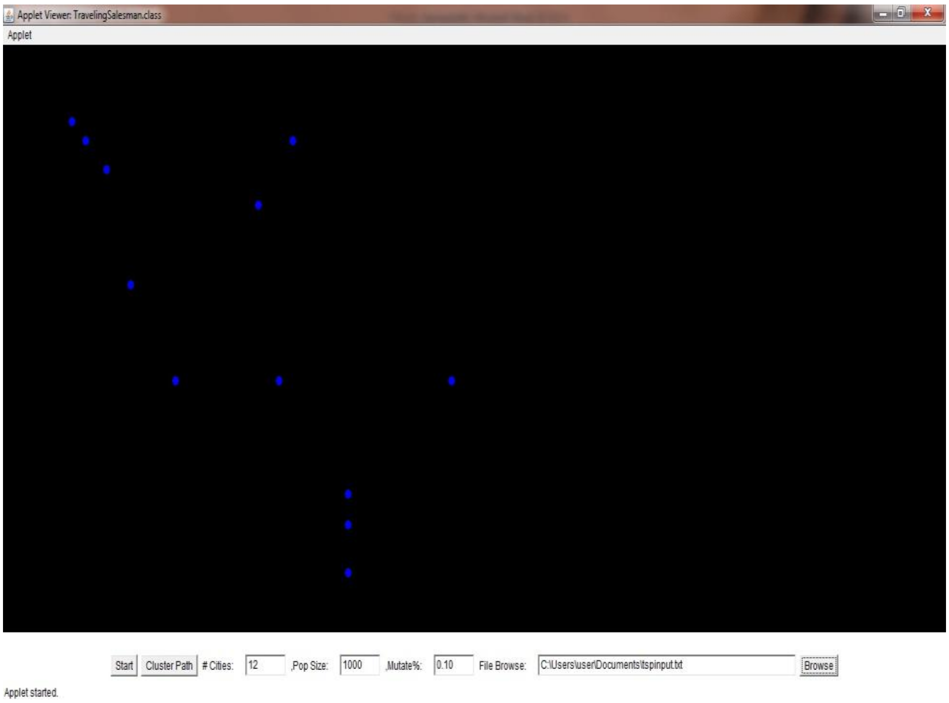
Population size says how many chromosomes are in population (in one generation). If there are too few chromosomes, GA have a few possibilities to perform crossover and only a small part of search space is explored. On the other hand, if there are too many chromosomes, GA slows down.

Mutate:

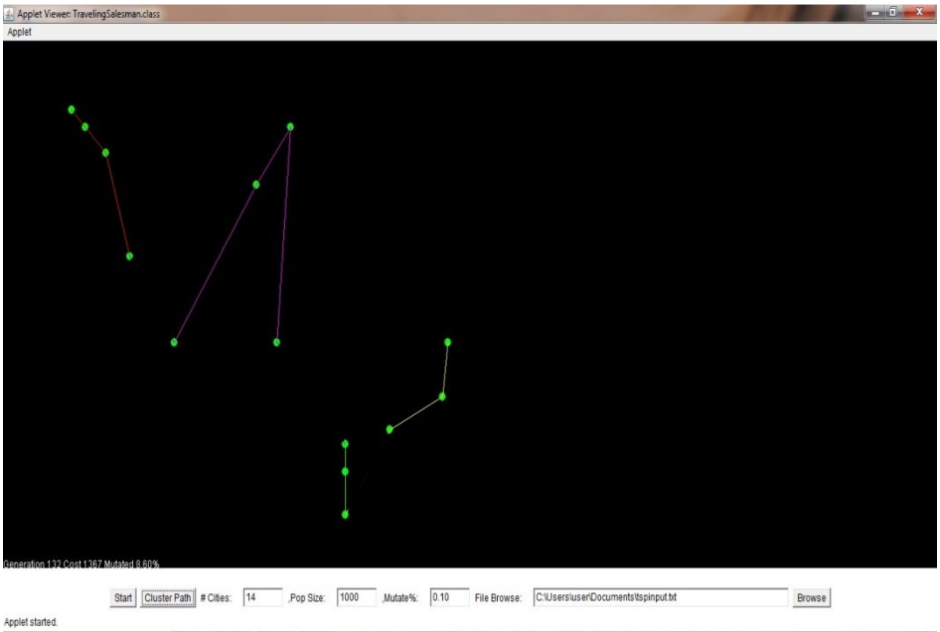
Mutation is a divergence operation. It is intended to occasionally break one or more members of a population out of a local minimum/maximum space and potentially discover a better minimum/maximum space.

File Browse:

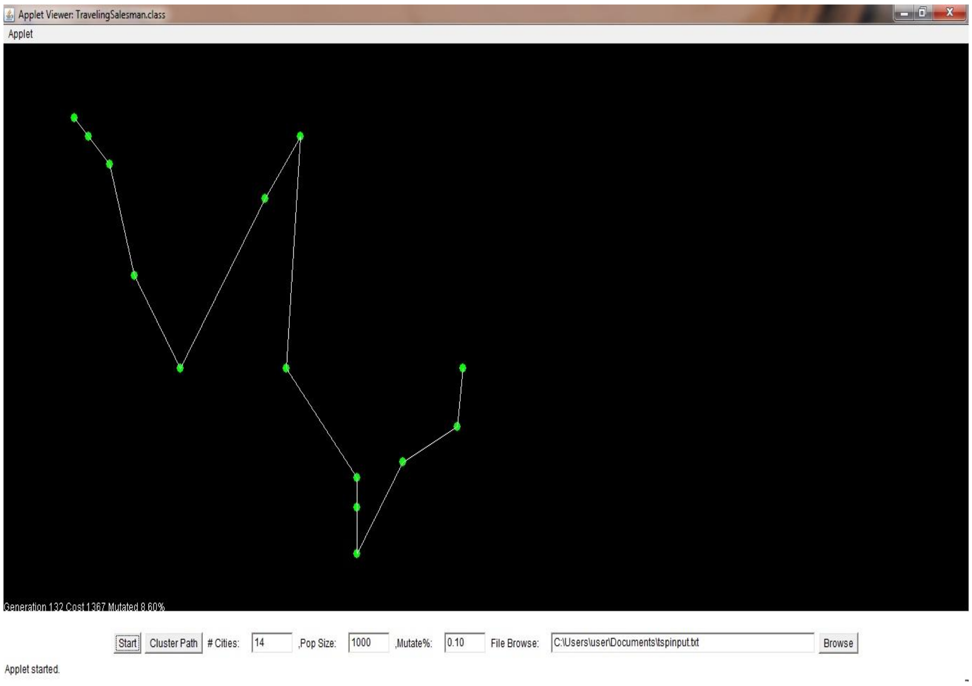
It provide a option to browse a file which takes universal problem as input.



After the file browsing , the points get plotted on applet screen. The user can manually provide the input data sets.



Clusters are formed shown by different colors. The clusters are formed based on K means algorithm.



The final optimal path is shown in above figure.

III. Conclusion

A two-level genetic algorithm for the CTSP was developed, which realized the integrated evolutionary optimization for both levels of the CTSP. In TLGA, a shortest Hamiltonian cycle is formed instead of the shortest Hamiltonian path for each cluster in the lower level genetic algorithm, and then the higher level genetic algorithm is free to choose end vertices for each cluster. The TLGA favor's, neither the intra-cluster Hamiltonian paths nor the inter-cluster paths, thus it can get a shorter tour for the CTSP.

Acknowledgement

The heading of the Acknowledgment section and the References section must not be numbered.

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