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A STUDY ON OPTIMIZATION TECHNIQUES OF TRAVELLING SALESMAN PROBLEM USING GENETIC ALGORITHM

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ABSTRACT

One way to approach the Travelling salesman problem (TSP) is to use an Evolutionary algorithm. Genetic algorithm is a randomized search technique and derivative free optimization. Genetic Algorithm has several uses such as problem solver, basis for competent machine learning. Travelling salesman problem has two constraints which can be one city at a time and each city visited once and only once to find its optimization. But with the increase in the number of cities, the complexity of the problem goes on increasing. In this paper, we have solved Travelling Salesman Problem using Genetic algorithm approach. System starts from a matrix of the calculated Euclidean distances between the cities to be visited by the travelling salesman and randomly chosen city order as the initial population. Then new generations are created repeatedly until the proper path is reached upon reaching a stopping criterion.

KEYWORDS

TSP, GA, fitness value, selection, 2-point crossover, interchange mutation.

I. INTRODUCTION

The travelling salesman problem (TSP) is the most well-known optimization problem. TSP is used to find a routing of a salesman who starts from a home location, visits a prescribed set of cities and returns to the original location in such a way that the total distance travelled is minimized and each city is visited exactly once [1]. TSP is solved very easily when there is less number of cities, but as the number of cities increases it is very hard to solve, as large amount of computation time is required. The numbers of fields where TSP can be used very effectively are military and traffic. Another approach is to use genetic algorithm to solve TSP because of its robustness and flexibility [2]. Some typical applications of TSP include vehicle routing, computer wiring, cutting wallpaper and job sequencing.

II. TRAVELLING SALESMAN PROBLEM

The Travelling salesman problem is defined as a permutation problem with the objective of finding the path of the shortest length (or the minimum cost). TSP can be modeled as an undirected weighted graph, such that cities are the graph's vertices, paths are the graph's edges, and a path's distance is the edge's length. It is a minimization problem starting and finishing at a specified vertex after having visited each other vertex only once. Often, the model is a complete graph. If no path exists between two cities, adding an arbitrarily long edge will complete the graph without affecting the optimal tour. Mathematically, it can be defined as given a set of n cities, named {p1, p2,…pn}, and permutations, σ1,..., σn!, the objective is to choose σi such that the sum of all Euclidean distances between each node and its successor is minimized. The successor of the last node in the permutation is the first one. The Euclidean distance d, between any two cities with coordinate (x1, y1) and (x2, y2) is calculated by equation 1 [3].

$d=\sqrt{(|X1-X2|)^2+(|Y1-Y2|)^2}$ (1)

The most popular practical application of TSP are regular distribution of goods or resources, finding of the shortest of costumer servicing route, planning bus lines etc., but also in the areas that have nothing to do with travel routes[4].

III. VARIOUS APPROACHES USED FOR SOLVING TSP

In 1997, Rong Yangintroduce several knowledge-augmented genetic operators which guide the genetic algorithm more directly towards better quality of the population but are not trapped in local optima prematurely. The algorithm applies a greedy crossover and two advanced mutation operations based on the 2-opt and 3-opt heuristics [5].In 2001, Chiung Moon introduces the concept of topological sort (TS), which is defined as an ordering of vertices in a directed graph.Also, a new crossover operation is developed for the proposed GA [6].In 2004, new knowledge based multiple inversion operators and a neighbourhood swapping operator is proposed by Shubhra Sankar Ray [7].In 2005, Lawrence V. Snyder presents a heuristic to solve the generalized traveling salesman problem.

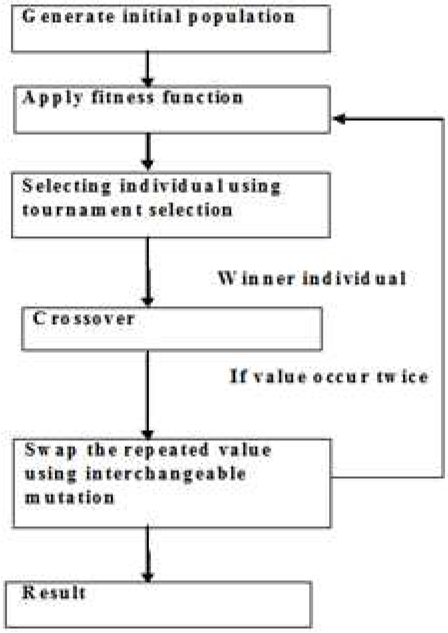
The procedure incorporates a local tour improvement heuristic into a random-key genetic algorithm. The algorithm performed quite well when tested on a set of 41 standard problems with known optimal objective values [8]. In 2005, Milena Karova introduces the solution, which includes a genetic algorithm implementation in order to give a maximal approximation of the problem, modifying a generated solution with genetic operators [9].In 2006, PlamenkaBorovska investigates the efficiency of the parallel computation of the travelling salesman problem using the genetic approach on a slack multicomputer cluster [10].In 2007, 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 [11].In 2007, A novel particle swarm optimization (PSO)-based algorithm for the travelling salesman problem (TSP) is presented, and is compared with the existing algorithms for solving TSP using swarm intelligence [12].In 2008, A software system is proposed to determine the optimum route for a Travelling Salesman Problem using Genetic Algorithm technique [3].In 2009, S.N. Sivanandam presents two approaches i.e Genetic Algorithms and Particles warm optimisation to find solution to a given objective function employing different procedures and computational techniques; as a result their performance can be evaluated and compared [13].

In 2010, a novel hybrid discrete PSO algorithm has been presented by add heuristic factor, crossover operator and adaptive disturbance factor into the approach. Numerical results show that the proposed algorithms are effective [14].In 2011, Ivan Brezina Jr. discusses the Ant Colony Optimization (ACO), which belongs to the group of evolutionary techniques and presents the approach used in the application of ACO to the TSP [4].In 2011, a comparative performance of roulette wheel, Elitism and tournament selection method is presented to solve the Travelling Salesman problem [16].In 2012, different authors present a critical survey to solve TSP problem using genetic algorithm methods[15].

IV. PROPOSED GENETIC ALGORITHM

John Holland proposed Genetic Algorithm in 1975. In the field of artificial intelligence genetic algorithm is a search heuristic that mimics the process of natural evolution. Genetic Algorithm belongs to class of evolutionary algorithm. GA begin with various problem solution which are encoded into population, a fitness function is applied for evaluating the fitness of each individual, after that a new generation is created through the process of selection, crossover and mutation. After the termination of genetic algorithm, an optimal solution is obtained. If the termination condition is not satisfied, then algorithm continues with new population [2].

FIG. 1: THE FLOWCHART FOR PROPOSED GA



The distance matrix of the problem is given in table 1. We have assumed the distance-matrix to be symmetric; therefore, the part above the main diagonal contains all necessary information. The first row and column denotes the city.

TABLE I - DISTANCE MATRIX OF 6 CITIES PROBLEM

	Delhi	Mumbai	Calcutta	Pune	Bangalore	Chennai
Delhi	0	90	100	35	300	200
Mumbai	90	0	60	120	400	290
Calcutta	100	60	0	70	480	225
Pune	35	120	70	0	320	150
Bangalore	300	400	480	320	0	290
Chennai	200	290	225	150	290	0

Delhi = 1
Mumbai = 2
Calcutta = 3
Pune = 4
Bangalore = 5
Chennai = 6

A. Initial Population

Initial population of chromosomes is created randomly by using unique random number generator function in Matlab. The initial population created is shown in following section. The population consists of four chromosomes, where each chromosome denotes the sequence in which cities have to be traversed and each gene represent the number assigned to a city.

Pop 1:	2	1	3	4	5	6
Pop 2:	1	2	3	5	4	6
Pop3:	1	4	3	2	6	5
Pop4:	5	3	2	1	4	6

B. Fitness Value

The Purpose of the fitness function is to decide if a chromosome is good then how good it is? In the travelling salesman problem, the criteria for good chromosome is its length. Calculation takes place during the creation of the chromosomes as given in equation 2. Each chromosome is created and then its fitness function is calculated. The length of the chromosome is measured in pixels by the scheme of the tour [11].

$$\text{fitness chromosomes} = \sum_{i=1}^{\text{towncount}} t1$$

towncount = total number of cities

ti = distance between two cities

P1= (2 1 3 4 5 6)

= (2,1)+(1,3)+(3,4)+(4,5)+(5,6)+(6,2)

= 90+100+70+320+290+290

= 1060 Km.

P2 = (1 2 3 5 4 6)

= (1,2)+(2,3)+(3,5)+(5,4)+(4,6)+(6,1)

= 90+60+480+320+150+200

= 1300 Km.

P3 = (1 4 3 2 6 5)

= (1,4)+(4,3)+(3,2)+(2,6)+(6,5)+(5,1)

= 35+100+60+290+300

= 1045 Km.

P4 = (5 3 2 1 4 6)

= (5,3)+(3,2)+(2,1)+(1,4)+(4,6)+(6,5)

= 480+60+90+35+150+290

= 1045 Km.

Tournament selection:

P1 = 1060 Km. }
P2 = 1060 Km. }
P3 = 1060 Km. }
P4 = 1060 Km.

C. Selection

Selection is used to select the chromosome whose fitness value is small. We have used the tournament selection by using Sorting method.
Here P1 and P3 winning unit.

D. Crossover

2-point crossover is applied to the pair of chromosomes so that new chromosomes will be generated which might have better fitness value. In 2-point crossover, randomly two positions in the chromosomes are chosen and then replace the gene with each other in both

P1 =1060 Km = 2 1 | 3 4 5 | 6 => 2 1 3 2 6 6

P2 =1045 Km = 1 4 | 3 2 6 | 5 =>1 4 3 4 5 5

E. Mutation

Mutation is applied to form a new generation. We apply interchange mutation, randomly select two genes from a chromosomes and the swap them.

2 and 5 are twice

4 = 2

5 = 6

P1 = (2 1 3 4 5 6) } Offspring

P3 = (1 2 3 4 6 5)

Fitness Population:

P1= (2 1 3 4 5 6)

= (2,1)+ (1,3)+ (3,4)+ (4,5)+ (5,6)+ (6,2)

= 90+100+70+320+290+290

= 1060 Km.

P3= (1 2 3 4 5 6)

= (1,2)+ (2,3)+ (3,4)+ (4,5)+ (5,6)+ (6,1)

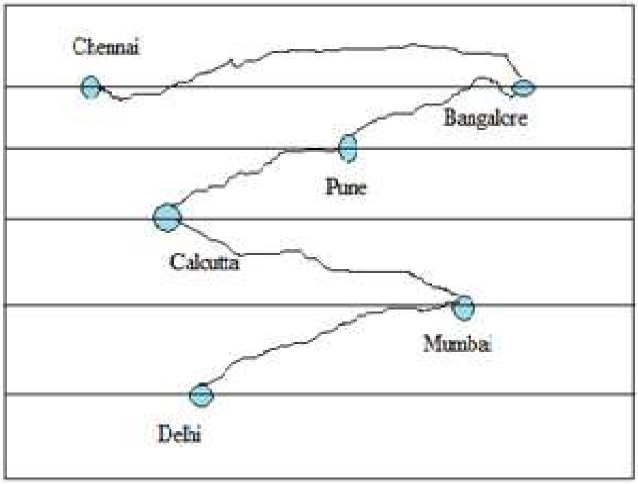
= 90+60+70+320+290+200

= 1030 Km.

F. Termination and Result

After completing the number of iterations the best tour will be obtained and the process will be terminated. The tour obtained with minimum distance is as shown in figure 3 for the problem of 6 cities.

FIGURE 3: GRAPH DENOTING BEST PATH OBTAINED FOR 6 CITIES



V. RESULT AND ANALYSIS

We have solved a total of 4 populations. The best and worst results obtained in table II. The same table denotes the best results of the problems presents in literature. Looking at results in the optimization technique

VI. CONCLUSION AND FUTURE SCOPE

Combining the information from heuristic methods and genetic algorithms is a promise approach for solving the TSP. Genetic algorithms appear to find good solutions for the travelling salesman problem, however it depends very much on the way the problem is encoded and which crossover and mutation methods are used. A number of genetic algorithm techniques have been analysed and surveyed for solving TSP. The research work can be extended for different hybrid selection, crossover and mutation operators. The proposed approach can be applied for various advanced network models like logistic network, task scheduling models, vehicle navigation routing models etc. The same approach can also be used for allocation of frequencies in cells of cellular network.

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