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Segregation of Various Crossover Operators in TSP using G.A

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Abstract

The traveling salesman Problem is considered to be a N.P Hard Problem. Genetic Algorithm (GA) is an approximate algorithm that doesn't always aim to find the shortest tour but to find a reasonably short tour quickly. Crossover operators play important role in G.A. In this paper various crossover operators are used. The results shows that PMX is best among all.

Keywords

Genetic Algorithm, TSP, Selection, Crossover, Mutation, PMX, CX, OX

I. Introduction

The Traveling Salesman Problem (TSP) is a classical problem of combinatorial optimization of Operations Research's area. The purpose is to find a minimum total cost. The TSP has received considerable attention over the last two decades and various approaches are proposed to solve the problem, such as branch-and-bound, cutting planes simulated annealing ,neural network , and tabu search. More recently, Genetic Algorithm (GA) approaches are successfully implemented to the TSP. Genetic algorithms were first proposed by the Holland in the 1960s [1]. Genetics algorithm based on the principle of genetics and evolution. Genetic algorithms use the principles of selection and evolution to produce several solutions to a given problem. Genetic algorithms tend to thrive in an environment in which there is a very large set of candidate solutions and in which the search space is uneven and has many hills and valleys.

II. Genetic Algorithm

Genetic algorithms are one of the best ways to solve a problem for which little is known. They are a very general algorithm and so will work well in any search space. All you need to know is what you need the solution to be able to do well, and a genetic algorithm will be able to create a high quality solution.
The basic steps involved are:

A. Initialization

The first step is to generate Initial Population from individuals. An Individual is a single solution [6]. A problem may contain thousand of possible solution. All these possible solutions then constitute a search space. Here for N no. of cities, possible solutions can be found N!

B. Encoding

Encoding is a process of representing individual genes. The process can be performed using bits, numbers, trees, arrays, lists or any other objects.
Using Permutation encoding cities can be represented by numbers.
For ex. If we have 8 cities then these can be rep. as
Chromosome A: 4 5 6 1 9 10 2 3

C. Fitness Function

A Fitness function is considered as a function that can assign a score to any possible solution. The score is a numerical value that indicates how well a particular solution solves the problem [1]. In TSP fitness function can be found by calculating distance between the cities.

D. Selection

The selection operator selects chromosomes from the current generation that will create offspring for the next generation. While there are many different types of selection, we use the most common type - roulette wheel selection.

1. Roulette Wheel Selection

In Roulette Wheel selection, one slice is assigned to each individual where the size is proportional to the individual's fitness. The wheel is spin N times, where N is the number of individuals in the population. After every spin the marker value is selected to be in the pool of parents for the next generation [1].
This method is implemented as follows:
(i). Sum the total fitness value of the individuals in the population.
Let it be f.
(ii). Repeat N times:

- Choose a random integer 'p' between o and f.

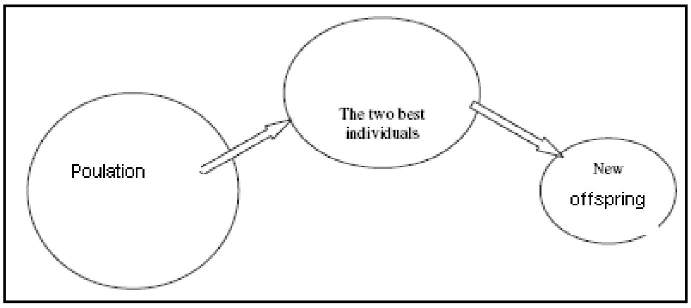

Fig. 1: Showing the Selection Process

- Loop through population, summing the fitness values, until the sum is greater than or equal to 'p'. The individual whose expected value puts the sum over this limit is the one selected. [2]

E. Crossover

Crossover is the operator that creates a child by combining two parents together.
The idea behind crossover is that the new chromosome may be better than both of the parents if it takes the best characteristics of each of the parents. [1]
Here we use three crossover operators PMX, CX & OX.

1. Partially Matched Crossover

The Partially Matched Crossover (PMX) [3] was proposed by Goldberg and Lingle which produces the offspring by selecting a sub sequence of a tour from one parent and maintains the order and position of cities in other parent.

Consider the following parents:
P1: 4 1 2 3 6 9 8 5 10 7
P2: 10 8 9 1 4 5 7 6 2 3

The offspring produced are:
O1: 6 1 2 3 4 5 7 6 10 8
O2: 10 7 5 1 6 9 8 5 2 3

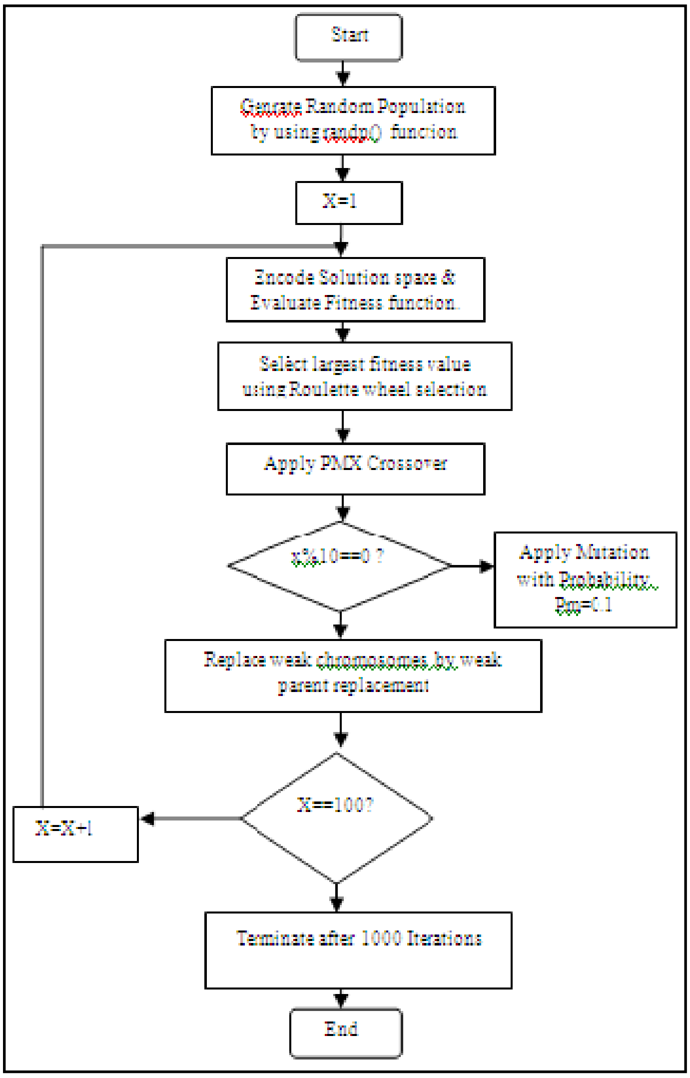

Fig. 2: Showing the Steps Involved in Partially Matched Crossover

2. Cyclic Crossover

The Cyclic Crossover (CX) [4] was suggested by Oliver et al, which create off springs from parents in which each position is occupied by corresponding element from one of the parents. Cyclic crossover takes attention that each gene comes from the parent or the other.

Consider the following parents:
P1: 1 2 4 6 3 5 7 8
P2: 8 6 7 1 4 3 5 2

The offspring produced are:
O1: 1 2 7 6 4 3 5 8
O2: 8 6 4 1 3 5 7 2

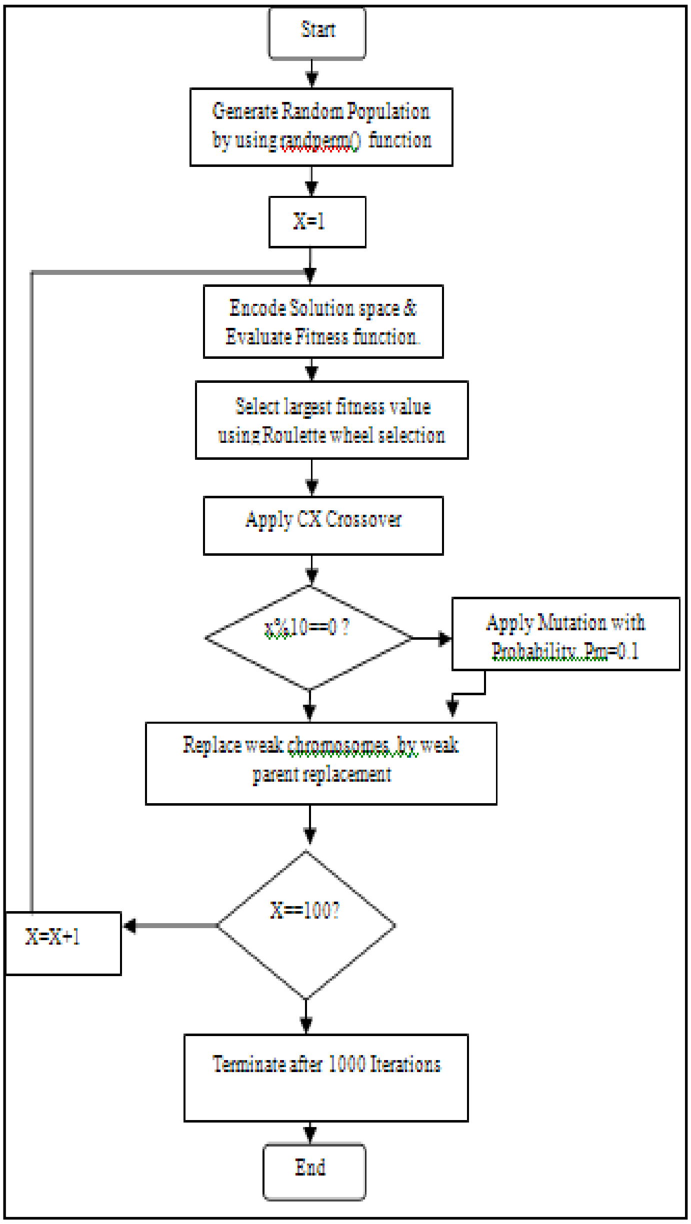

Fig. 3: Showing the Steps Involved in Cyclic Crossover

3. Ordered Crossover

The Ordered Crossover (OX) [5] was proposed by Davis which produces an offspring by selecting a sequence of parent and preserves the relative order of cities in other parent.

Consider the following parents:
P1: 4 2 1 3 6 5
P2: 2 3 1 4 5 6

The offspring produced are:
O1: 4 2 3 1 6 5
O2: 2 3 4 1 5 6

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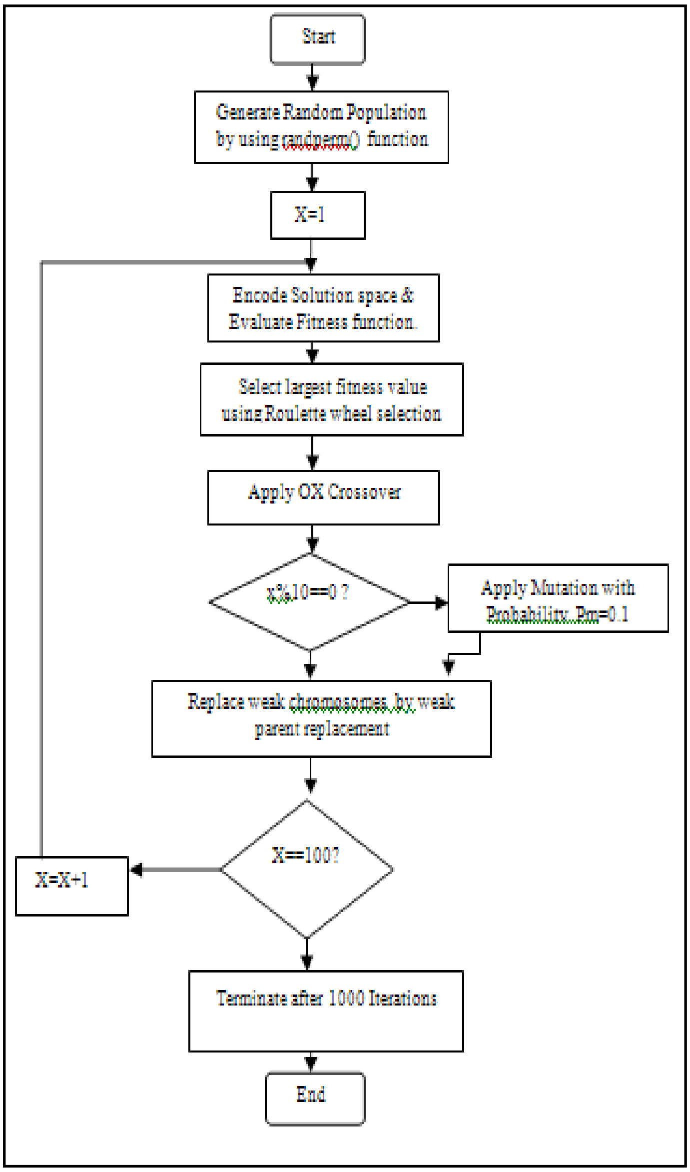

Fig. 4: Showing the Steps Involved in Ordered Crossover

F. Mutation

Mutation is applied after crossover in order to prevent the algorithm to be trapped in local minima.
Here we use interchanging Mutation in which two random positions are chosen and the respective chromosomes are interchanged.

G. Replacement

In Replacement Procedure two Parents are selected and they produced two child. But all four cannot be return to the population. Hence the two must be replaced. Here in TSP we use Weak Parent Replacement.

1. Weak Parent Replacement

In this Procedure the stronger of the two children replaces the weaker parent. So only the fittest two return to the population.

H. Termination Criteria

The algorithm will terminate after 1000 iterations.

III. Results

The graph below shows the distance find out by
PMX, CX and OX operator with 25 no. of cities and P_c =1 and P_m=0.1

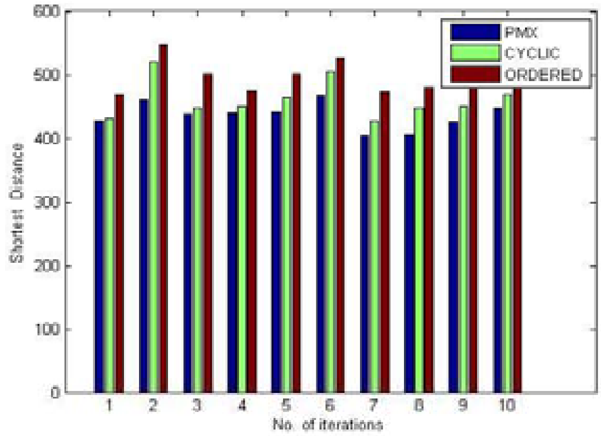

Fig. 5: Showing the Results with 25 Cities

The graph below shows the distance find out by
PMX, CX and OX operator with 30 number of cities and P_c=1 and P_m = 0.1.

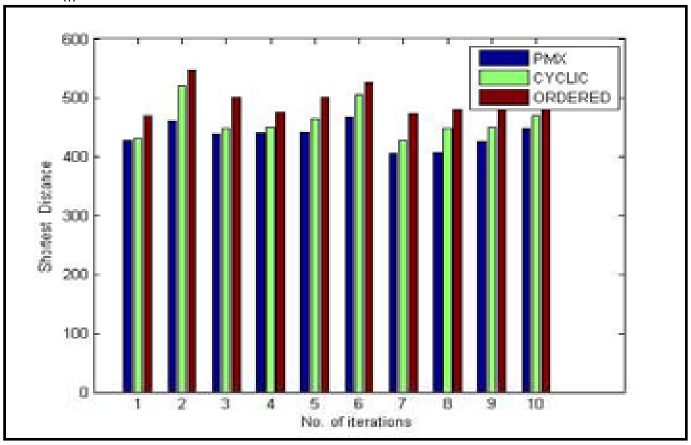

Fig. 6: Showing the Results with 30 Cities

IV. Conclusion

The Experimental results show that the PMX crossover surpasses the OX and CX crossover by providing the best result. Hence PMX Crossover is considered to be the best among all three crossovers.

Table 1: Result of PMX, CX and OX

No. of Cities	PC Crossover Probability	PM Mutation Probability	Average Distance By PMX	Average Distance By CX	Average Distance By OX
25	1	0.1	428	483	503
30	1	0.1	436	461	493

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