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Shared Crossover Method for Solving Traveling Salesman Problem

Mouhammd Al kasassbeh, Ahmad Alabadleh, Tahsen Al-Ramadeen

[1] Information Technology Department, Mutah University, Karak, Jordan

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Abstract. Genetic algorithms (GA) are evolutionary techniques that used crossover and mutation operators to solve optimization problems using a survival of the fittest idea. They have been used successfully in a variety of different problems, including the traveling salesman problem. The main idea of Traveling Salesman Problem (TSP) is to find the minimum traveling cost for visiting cities; the salesman must visit each city exactly once and return to the starting point of origin. Genetic algorithms are search methods that employ processes found in natural biological evolution. These algorithms search on a given population of potential solutions to find those that pass some specifications or criteria. In this paper, we apply modified genetic algorithm methodology for finding near-optimal solutions for TSP problem using shared neighbours to insure that the closest cities to have the highest priorities to be carried out to the next generation.

Keywords: *Traveling Salesman Problem (TSP), Genetic Algorithm (GA), Order Crossover (OX), Swap Crossover, Shared Crossover.*

1. Introduction

1.1. Traveling Salesman Problem (TSP)

The main idea of the TSP is the discovery of the shortest possible tour path through a given set of nodes or cities. The comprehensive surveys of works on the TSP can be found in [1-6]. Researchers have suggested genetic algorithms (GA's) for solving TSP [7]. The TSP is one of the significant subjects, which has been widely addressed by mathematicians and computer scientists. Its importance stems from the fact, there is a plenty of fields in which finds potential applications such as DNA fragment assembly and VLSI design. Formally, the TSP may be defined as follows [8].

It is a combination problem with the objective of finding the path of the shortest length (or the minimum cost) on an undirected graph that represents cities or nodes to be visited. The traveling salesman begins at one node, visits all other nodes consecutively only once, and finally returns to the starting point. In other words, given n cities, named {c1, c2, …, cn}, and permutations, {σ1, σ2, …, σn}, the goal 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.

$$d = \sqrt{(x_1 - x_2)^2 + (y_1 - y_2)^2} \tag{1}$$

And the minimum total distance is calculated as follows;

$$Minimize\left[\sum_{i=1}^{N-1} d\left(c_i, c_{i+1}\right) + d\left(c_N, c_1\right)\right] \tag{2}$$

Recently, Robert Bosch [9] created a 100,000-city instance of the traveling salesman problem (TSP) that provides a representation of Leonardo da Vinci's Mona Lisa as a continuous-line drawing. An optimal solution for this case set a new world record for the TSP. The current best known results for the Mona Lisa TSP are; Tour: 5,757,191, Bound: 5,757,044 and Gap 147 (0.0026%). The tour was found on March 17, 2009, by Yuichi Nagata [9]. The bound ***B*** is given such that no tour has length less than B; this bound was found on November 4, 2009, with the Concorde code [9].

The remainder of this paper is organized as follows: in Section 2, we discuss related work .Section 3 the problem statement. In Section 4 provides an overview of our new crossover technique to solve the TSP. The discussion and the comparison between OX, swap and our proposed shared crossover are illustrated in Section 5. Finally, we summarize and conclude in Section 6.

1.2. Genetic Algorithms (GA)

Genetic Algorithms are search algorithms developed by Johan Holland in the 1970's [5], it can be used to solve a variety of problems that are not easy to solve using other techniques. Fundamentally, Genetic Algorithms consist of the three basic operations, selection operation, crossover operation, and mutation operation. When we use a GA to solve a problem, random possible solutions will be generated, each one of them will be tested until we have a best solution, then it will be good enough for a specific problem.

Selection operation used to select a random possible solution from a set of population called chromosomes using fitness function, which is determined by the type of the problem. The crossover operation used to produce new chromosomes called children chromosomes from the parent chromosomes by choose a randomly crossover point. Finally, the mutation used to make some change on the children chromosomes to make the solution very close to the realty. Figure 1 illustrates the simple GA structure.

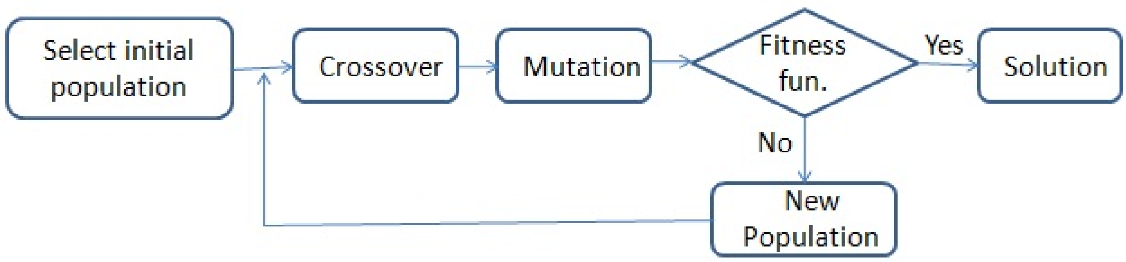

Figure 1: The structure of a simple genetic algorithm

Moreover, to illustrate GA operations, here is a very simple example:
Suppose we have the following population:

No	Chromosome
1	1001100011
2	1110001111
3	1010101011
4	1100110011

- Selection : suppose we select chromosome 1 and 3
- Crossover: suppose the crossover point is 4

Parent 1: 1001 | 100011 Child 1 : 1001101011

Parent 2: 1010 | 101011 Child 2 : 1010100011

- Mutation : Usually done with small probability

Child 1: 1 0 0 0 1 0 1 0 1 1 Child 2: 1 0 1 0 1 0 0 0 0 1