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Travelling Salesman Algorithm Applications

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***Abstract*—The Traveling Salesman Problem (TSP) is to find a shortest tour that stops at each city exactly once for a given list of cities and return back to the initial city. In this paper, some methods are studied in order to solve the Traveling Salesman Problem. This paper shows some theories that are related in solving the TSP. The aim of this paper is to show the applications and solution for the traveling salesman algorithm at the end of the paper.**

Keyword: **Travelling Salesman Algorithm Applications, TSP**

I. INTRODUCTION

The Traveling Salesman Algorithm (TSP) was initially figured as a mathematical issue in 1930 and turned out to be progressively prominent after 1950. It is a standout amongst the most seriously examined issues in advancement even lately. The TSP is to locate a most brief conceivable visit that stops at each city precisely once for a given rundown of urban communities and return to the beginning city [1-3]. TSP take part in an essential part in Operations Research, Applied Mathematics and Computational Physics [4]. TSP is a well-known NP-hard combinatorial optimization problem [2, 5] or NP-hard benchmark problem for discrete optimization [6]. Because of their simplicity to portray and hardnzess to solve, TSP examples have gotten to be combinational benchmarks to survey the execution of various heuristic advancement techniques [6]. The aim of this article is to show how TSP works and its application in reality does.

This paper is organized as background is described in Section 2, Section 3 explains about methodology in mathematical theory that involve in traveling salesman problem. In section 4, the applications of TSP are show. Finally, the conclusion is given in Section 5.

II. BACKGROUND

Until now there are many research had been done about TSP. For example, variation of the usual travelling salesman problem (TSP) is the clustered travelling salesman problem (CTSP) [7]. The contribution of an occasion of the issue is for the most part an arrangement of points in a metric space that are to be stop by in a way that the final time is decreased [8-10].

III. METHODOLOGY

The aim of the TSP is to get a path that passes through every city precisely once, and go back to the initial city, such that the total cost of traveling is decreased [11]. Given cost matrix $C = (c_{ij})_{i,j = 0,1,2,n}$, where c_{ij} is the cost of going from city i to city j,

$$\min_{\theta \in \Theta} f(\theta) \equiv \min_{\theta \in \Theta} (c_{i_0 i_1} + c_{i_1 i_2} + \cdots + c_{i_n i_0}),$$

Partitioning:

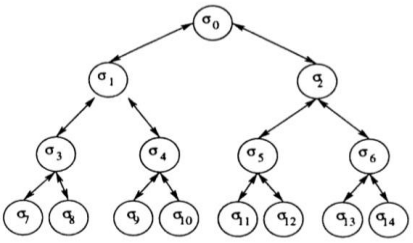

Figure 1. Partitioning by NP method

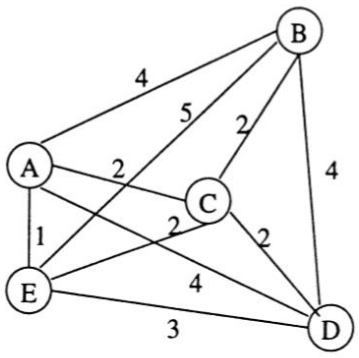

Figure 2. TSP example

Example. As a first step, store the edges in an adjacency list and sort every of the jointed that are related to the cities. For example, in the Figure 3, the initial row show a connected list for city A, that is E is the city nearest to A, C is the city second nearest to A, B is the city next nearest to A, and D is the city least close to A.

City	Closest two		Next two	
A →	E →	C →	B →	D
B →	C →	A →	D →	E
C →	A →	B →	D →	E
D →	C →	E →	A →	B
E →	A →	C →	B →	D

Figure 3.

IV. APPLICATIONS

Based on research paper done by researchers from University of the Basque Country which make another study about variety tries to unravel the TSP with Genetic Algorithms [12]. Below shows some of the representation being used in unravelling the TSP. For examples, path representation.

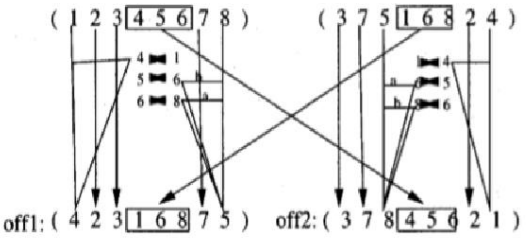

Figure 4.Partially-mapped crossover operator (PMX) [12].

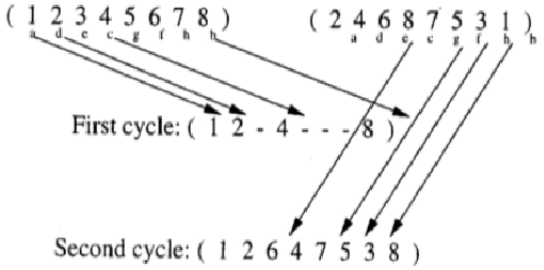

Figure 5. Cycle crossover (CX) [12].

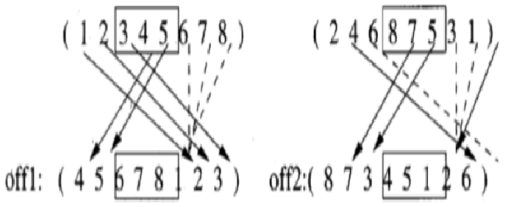

Figure 6. Order crossover (OX1) [12].

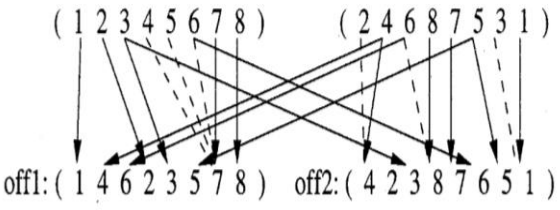

Figure 7. Position based crossover (POS) [12].

Representation	Operators	Authors
Binary	Classical + repair operator	Lidd (1991)
Path	Partially-mapped crossover	Goldberg and Lingle (1985)
	Order-crossover	Davis (1985)
	Order based crossover	Syswerda (1991)
	Position based crossover	Syswerda (1991)
	Heuristic crossover	Grefenstette (1987b)
	Edge recombination crossover	Whitley et al. (1989)
	Sorted match crossover	Brady (1985)
	Maximal preservative crossover	Mühlenbein et al. (1988)
	Voting recombination crossover	Mühlenbein (1989)
	Alternating-positions crossover	Larrañaga et al. (1996a)
	Displacement mutation	Michalewizc (1992)
	Exchange mutation	Banzhaf (1990)
	Insertion mutation	Fogel (1988)
	Simple inversion mutation	Holland (1975)
	Inversion mutation	Fogel (1990)
	Scramble mutation	Syswerda (1991)
Adjacency	Alternating edge crossover	Grefenstette et al. (1985)
	Subtour chunks crossover	Grefenstette et al. (1985)
	Heuristic crossover 1	Grefenstette et al. (1985)
	Heuristic crossover 2	Jog et al. (1989)
	Heuristic crossover 3	Suh and Van Gucht (1987)
Ordinal	Classical operators	Grefenstette et al. (1985)
Matrix	Intersection crossover operator	Fox and McMahon (1987)
	Union crossover operator	Fox and McMahon (1987)
	Repair operators	Seniw (1981)
	Repair operators	Homaifar and Guan (1991)
	Heuristic inversion mutation	Homaifar and Guan (1991)

Figure 8. Summation of representations and operators [12].

Other than that, based on paper an iterated local search TSP with Pickups and Deliveries (TSPPD) includes in outlining a basic cost visit that begins at the stop, gives either a pickup administration to every of the clients and return back to the warehouse, in a manner that the vehicle limit is not surpassed in any part of the visit [13]. In the paper, the TSPPD is solved by considering a metaheuristic algorithm based on Iterated Local Search with Variable Neighborhood Descent and Random neighborhood ordering [13].

Next, paper from Ant colonies for the travelling salesman problem, they used artificial ant to solve the TSP. In the article they restrict attention to TSPs in which cities are on a plane and a path (edge) exists between each pair of cities [14].

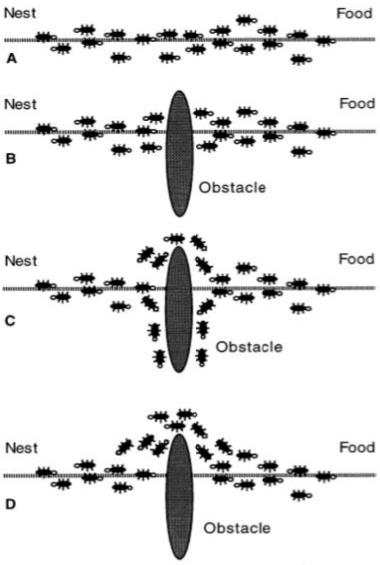

Figure 9. Real ant

Based on Figure 6, (A) show real ants tail a route between nest and food source. (B) A problem happens on the route. The ants decide whether to turn left or right with same possibility. Pheromone is consigned faster on the shorter path. (D) All ants have decided the shorter path [14].

V. CONCLUSION

As a conclusion, through this research, the TSP works have been shown and there many applications that have been done to solve the TSP problem. It also shows some theories that are related in solving the TSP as well as the applications and solution for the traveling salesman algorithm to be properly applied.

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