A Review of the Optimization Algorithms on Traveling Salesman Problem

Article *in* Indian Journal of Science and Technology · November 2015

DOI: 10.17485/ijst/2015/v8i1/84652

Sathya Nagarajan
Vels University

ISSN (Print) : 0974-6846
Indian Journal of Science and Technology, *Vol 8(29), DOI: 10.17485/ijst/2015/v8i1/84652, November 2015* ISSN (Online) : 0974-5645

A Review of the Optimization Algorithms on Traveling Salesman Problem

N. Sathya*[*] and A. Muthukumaravel

Bharathiar University, Coimbatore - 641001, Tamil Nadu, India; sat.phd15@gmail.com
Department of MCA, Bharath University, Chennai - 600001, Tamil Nadu, India; muthu14673@gmail.com

Abstract

The Traveling Salesman Problem (TSP) is arguably the most prominent problem in combinatorial optimization. The simple way in which the problem is defined in combination with its notorious difficulty has stimulated many efforts to find an efficient solution procedure. The TSP is a classic tour problem in which a hypothetical salesman must find the most efficient sequence of destinations in his territory, stopping only once at each, and ending up at the initial starting location. Due to the combinatorial complexity of the TSP, approximate or heuristic solution procedures are almost always employed in practice. Few prospective applications of TSP includes ruling an optimized scan chains route in integrated chip testing, parcels collection and sending in logistics companies, and transportation routing problem. There have been many algorithms introduced to grant time competent solutions for the problem, both exact and approximate. This paper is a review of the recent research work done on various algorithm like genetic algorithm ,tabu search algorithm ,ant colony algorithm available with respective attributes to find the nearest optimal solution for the traveling salesman problem. It also relates the traveling salesman problem with the available algorithms and provides the advantages in providing a solution for TSP.

Keywords: Ant Colony Algorithm, Combinatorial Optimization , Meta Heuristics, Minimum Cost GA, Tabu Search

1. Introduction

The TSP is a classic tour problem in which a hypothetical salesman must find the most proficient sequence of destinations in his territory, stopping only once at each, and ending up at the initial starting location. Estimated or heuristic measures are approximately at all times employed in practice due to the combinatorial complexity of the TSP. The Pictorial and mathematical structure of the TSP is a graph in which the nodes, edges, vertices etc.. are termed as the attributes. The nodes are the cities available in the problem. Edges are the vectors connecting the pair of cities and each edge has a cost associated with it which can be distance, time or other attribute. If n is the input number of vertices representing cities, for a weighted graph G, the TSP problem is to find the cycle of minimum costs that visit each of the vertices of G exactly once.

There are many mathematical formulations for the TSP, employing a variety of constraints that enforce the requirements of the problem. Since this is not the appropriate forum for reviewing all of the potential formulations, one has been chosen in order to demonstrate how such a formulation is specified. The following notation is used:

n = The number of cities to be visited; the number of nodes in the network

i, j, k = Indices of cities that can take integer values from 1 to n

t = The time period , or step in the route between the cities

x_{ijt} = 1 if the edge of the network from i to j is used in step t of the route, and 0 otherwise

d_{ij} = The distance or cost from city i to city j

The problem requires starting from a given city,

*Author for correspondence

visiting subsequent cities, and returning to the starting city. The optimal solution choses the route that minimizes the total distance traveled. There are $(n-1)!$ possible tours. The following is an example of one linear programming formulations of the TSP problem (Vajda S. 1961):

2. Applications of TSP

The TSP has several applications even in its purest formulation, such as planning, logistics, and the manufacture of microchips. In many areas it appears as a sub problem. For a paradigm in DNA sequencing it is used as a sub problem. In DNA perception the city represents DNA fragments, and the distance represents a correspondence measure between DNA fragments. The TSP problem is significantly harder in many applications due to some added constraints such as some degree of resources or time. The verdict version of the TSP belongs to the class of NP-complete problems in the hypothesis of computational complexity. Thus, it is to be expected that the most awful case running time for any algorithm for the TSP increases exponentially with the number of cities.

3. Review Report

This paper presents the literature survey review of Travelling Salesman Problem (TSP). TSP belongs to the category of NP-hard problems. A various number of methods have been designed to solve this problem. The aim of this literature survey is to study and analyze the available algorithms to predict a prominent or optimal solution for TSP. TSP 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. There are many AI algorithms to find the shortest length path. In this segment we list a testimony on existing research works on AI algorithms.

In 2004, Long Jin, Sanmj Huai-Kuang Tsai, Jinn-Moon Yang, Yuan-Fang Tsai, and Cheng-Yan Kao[1] projected an evolutionary algorithm, called the Heterogeneous Selection Evolutionary Algorithm (HeSEA), for solving large TSP. They first analyzed the strengths and limitations of numerous well-known genetic operators, along with local search methods for TSPs from their solution qualities and mechanisms for preserving and adding edges. Based on that analysis, they proposed the new approach, HeSEA which integrates Edge Assembly Crossover (EAX) and Lin–Kernighan (LK) local search, through family competition and heterogeneous pairing selection.

In 2008, Sumanta Basu and Diptesh Ghosh[2] presented a survey that Tabu search is one of the most widely applied metaheuristic for solving the TSP. In this paper, we review the tabu search literature on the TSP, point out trends in it, and bring out some interesting research gaps in this literature.

In 2009, Rajan K and Anilkumar AK[3] proposed an innovative search algorithm motivated by the evolutionary optimization technique for the solution of TSP. They described new crossover operators and mutation operators suitable for solving TSP by GA with the availability of fast computing facilities, this search technique can be utilized to solve TSPs with large dimensions.

In 2012, Naveen Kumar, Karambir, Rajiv Kumar[4] stated that genetic algorithm is one of the best methods which is used to solve various NP-hard problem such as TSP. The natural evolution process is always used by genetic Algorithm to solve the problems. They presented a critical survey to solve TSP problem using genetic algorithm methods that are proposed by researchers. They observed that there is requirement to design new genetic operators that can enhance the performance of the GA used to solve TSP. There is lot of scope for the researcher to do work in this field in future.

In 2012, Anshul Singh and Devesh Narayan[5] highlighted that the Bee Colony Optimization is for solving the Traveling Salesman problem with its basic mechanism of bees foraging behavior and its efficiency in solving shortest path among various routes. Neighborhood search is useful when exploitation is desired. It can be applied after every bee cycle to enhance the quality of solutions.

In 2012, Sumanta Basu[6] stated that the Tabu search is one of the most widely applied meta heuristic for solving the TSP. In her paper, she reviewed the tabu search literature on the TSP and its variations, point out trends in it, and bring out some interesting research gaps in that literature.

In 2012, Krishna H. Hingrajiya, Ravindra Kumar Gupta, Gajendra Singh Chandel[7] affirmed that the Ant Colony Optimization (ACO) is a heuristic algorithm which has been proven a successful technique and applied to a number of Combinatorial Optimization

(CO) problems. There are several reasons for the choice of the TSP as the problem to explain the working of ACO algorithms it is easily understandable, so that the algorithm behavior is not obscured by too many technicalities; and it is a standard test bed for new algorithmic ideas as a good performance on the TSP is often taken as a proof of their usefulness. They presented an approach for solving traveling salesman problem based on improved ant colony algorithm.

In 2013, Saloni Gupta and Poonam Panwar[8] has proposed Genetic algorithms appear to find good solutions for the traveling 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 analyzed and surveyed for solving TSP. The research 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.

In 2014, Sonam Khattar and Dr. Puneet Gosawmi[9] has concluded in their paper how Genetic Algorithm can be used for solving the Traveling Salesman Problem. Genetic Algorithm finds the good solution for the TSP, depend upon the way how the problem is encoded and which types of crossover and mutation methods are used. A number of genetic algorithm techniques have been analyzed and surveyed for solving TSP.

4. Solutions for the TSP

Exact approaches to solving the TSP are successfully used only for relatively small problem sizes but they can guarantee optimality based on different techniques. These techniques use algorithms that generate both a lower and an upper bound on the true minimum value of the problem instance. If the upper and lower bound coincide, a proof of optimality is achieved. The standard technique for obtaining lower bounds on the TSP problem is to use a relaxation that is easier to solve than the original problem. Due to the nature of TSP, most common solutions to the problem were found to run feasibly only for a graph with small number of nodes. Not much research was encountered in the survey over problem space analysis of the Traveling Salesman problem.

4.1 Genetic Method

Genetic Algorithm is used to solve an optimization problems and Traveling Salesman Problem (TSP). As the number of cities increases the amount of computational time to solve this problem grows exponentially. These algorithms demand innovative solutions if they are to be solved within a reasonable amount of time.

4.2 Tabu Search Method

As per the literature survey the tabu search is said to be most widely used Meta heuristic procedures to solve combinatorial optimization problems. It is an improvement heuristic based on local search. It starts with an initial solution to the problem, (a tour in case of the TSP), calls it a current solution, and searches for the best solution in a suitably defined neighborhood of the solution. It then designates the best solution in the neighborhood as the current solution and starts the search process again. Tabu search terminates when certain terminating conditions, either involving execution time or maximum iteration count conditions, or solution quality objectives, or both, have been met.

4.3 Ant Colony Method

By analyzing the ants behavior the ACO algorithms are designed to search for a shortest path between their nest and a source of food. It is a relatively novel meta-heuristic technique and has been successfully used in many applications especially problems in combinatorial optimization. ACO algorithm models the behavior of real ant colonies in establishing the shortest path between food sources and nests.

5. Conclusion

This paper presents a glance of various approaches being used to solve TSP. Genetic algorithms depends very much on the manner the problem is fixed and which crossover and mutation methods are used. It works according to that and discover good solutions for the TSP. A number of genetic algorithm techniques have been analyzed and surveyed for solving TSP. BCO can be combined with other heuristic techniques such as k-opt local search, tabu search to get more superior results. Combining the knowledge from heuristic methods and genetic algorithms is a hopeful approach for solving the TSP.

Although all the algorithms have their individual identity and produce solutions according to that, combining two or more algorithms will lead us to reach a best prominent and optimal solution for TSP.

6. References

1. Jin L, Tsai S, Yang J, Tsai J, Kao C. An evolutionary algorithm for large traveling salesman problems. IEEE Transactions on systems, Man and Cybernetics-Part B: Cybernetics. 2004; 34(4):1718–29.
2. Basu S, Ghosh D. A Review of the Tabu Search Literature on Traveling Salesman Problems. Indian Institute of Management. 2008; 10(1):1–16.
3. Rajan K, Anilkumar. Genetically motivated search algorithm for solving Traveling salesman problem. SB Academic Review. 2009; XVI(1&2):19–31.
4. kumar N, Karambir, Kumar R. A Genetic algorithm approach to study Traveling salesman problem. Journal of Global Research in Computer Science. 2012; 3(3):33–8.
5. Singh A, Narayan D. A Survey Paper on Solving Traveling Salesman problem Using Bee colony optimization. International Journal of Emerging Technology and Advanced Engineering. 2012; 2(5):309–14.
6. Basu S. Tabu Search Implementation on Traveling Salesman Problem and Its Variations: A Literature Survey. American Journal of Operations Research. 2012; 2:163–73.
7. Hingrajiya KH, Gupta RK, Chandel GS. An Ant Colony Optimization Algorithm for Solving Traveling Salesman Problem. International Journal of Scientific and Research Publications. 2012; 2(8):1–6.
8. Gupta S, Panwar P. Solving Traveling salesman problem using genetic algorithm. International Journal of Advanced Research in Computer Science and Software Engineering (IJARCSSE). 2013; 3(6):376–80.
9. Khattar S, Gosawmi P. A Solution of Genetic Algorithm for Solving Traveling Salesman Problem. International Journal for Scientific Research and Development (IJSRD). 2014; 2(4):341–3.