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Review of different heuristic algorithms for solving Travelling Salesman Problem

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Abstract: Travelling Salesperson Problem (TSP) is one of the leading problems that are considered as an NP-hard. To tackle with this problem we don't have any best suitable algorithm that solves it in polynomial time. Although we have certain algorithms that gave better results. This paper reviews the heuristic algorithms which are used to solve the problem & account for optimal solution in case of smaller problem size & give sub-optimal solution for bigger problem size. A survey for each & every strategy used for solving TSP i.e. how they are modified with time & corresponding results obtained as per the modification. Here we take into account well recognized heuristic algorithms which are genetic algorithm, ant colony optimization, particle swarm optimization.

Keywords: TSP, GA, ACO, PSO

INTRODUCTION

The Travelling salesperson problem is a broadly recognized NP-hard problems; this implies that there is no solitary algorithm to solve itin the polynomial time. The nominal anticipated time to get optimal solution is exponential [1]. Its statement is illusorily easy& yet it remains one of the most perplexingissues in Operational Research. The widespreaduse of TSP are systematicsharing of items or assets, discovering of a shortesttrack, planning traffic lines etc., and also in the regions that do not need routing[1]. Our aim is to present an overview of various heuristic algorithms so far developed for the TSP.

TSP is a problem to find the best shortest suitable path by the salesperson to visit *n* cities so that we can reach each and every city exactly once & finally comes to the initial position with least resources utilization as well as time. It can be well represented by a graph *G* having *N* no. of cities and *E* no. of paths between cities.

Let G = (N, E) be a graph where N is a set of vertices representing cities and E is set of edges representing paths. Let C_{ij}be a cost matrix (or distance matrix) associated with E. C_{ij}can be defined in Euclidean Space as follows:

$$C_{ij} = \sqrt{(x_i - x_j)^2 + (y_i - y_j)^2}$$

The path with least values is considered as shortest path.

Genetic algorithm (GA) is a heuristic algorithm used in optimization problems which is inspired from natural phenomenon of evolution. It is based on "Survival of the Fittest". GA was first introduced in 1975 by John Holland. After finding its application in the world of computer it attracts many researchers towards it. GA is used for solving many problems of optimization. In GA the strategies used are selection, Crossover and mutation in order to find the optimal chromosomes from the population. Further amendments are proposed with time to improve its capability. It can be improved mainly by introducing different kinds of selection operator like tournament, roulette wheel, boltzman selection etc., crossover operators such as SCX, ERX, GNX & different mutation operator like insert, inversion, scramble, swap, flip etc.

M. Dorigo et al. were the first to introduce the concept of Ant System (AS). After this, it became an interesting issue in the field of research. Many new approaches are proposed by researchers for its enhancement.In ACO the real ant behavior is imitated to get the best suitable path by artificial agents. This algorithm is a meta-heuristic approach that is applied in various optimization problems. The artificial ants are used to mimic the behavior of natural ants[2]. The working of these ants is based on chemical called 'Pheromone' which is released by the ants on their path. This chemical helps other ants to locate them in order to get the food. The level of pheromone helps ants to choose the better path. Higher the pheromone level, more the ants follows that path.

Particle Swarm Optimization (PSO) is also a well-recognized heuristic method for optimization. It was first proposed by Eberhart& Kennedy in 1995. It is based on social behavior of swarms where swarm changes their path as they find best path from uncertain search space by exchanging the information. Here swapping strategy is used. It has become a popular algorithm due to the easy concept, simple implementation & high convergence. It is best suitable for scientific researches as well as for engineering applications.

APPLICATIONS

TSP is widely used in many engineering applications such as architectural designs, communication, planning, routing and various industrial problems. The most recognizable applications of TSP are vehicle routing, microchips manufacturing, DNA sequencing, logistics, resource allocation, job sequencing, computer wiring and many more.

LITERATURE REVIEW

This Paper offers the literature survey review of TSP. A various no. of methods have been designed to solve this problem. The aim of this literature survey is to study & analyze available algorithms to predict an optimal solution for TSP.

A. Ant Colony Optimization

In 2008, Bifan Li et al. [3] proposed a paper on ACO where the new ants remember the best solution present so far. The presented model was termed as Ants carrying Memory or Mant. In this paper they did some important work like introducing the previous knowledge of the TSP, Ant System& ACS &define the parameter used and explain about ants with memory and merge them in ACS, and then the results were obtained by modified ants and compare the efficiency of each algorithm. This algorithm is capable to unite into at least a proximate optimal solution swiftly. The presented algorithm is so easy as well as better performing.This algorithm suits for small and mid-size problems however in case of larger problem it may trap into local optima.

In 2008, L Li et al. [4] present an enhanced ACO for solving TSP. In the paper they proposed a selection mechanism that is based on Held-Karp lower bound to obtain the optimal path for TSP. it obtains information from deposition of pheromone & heuristic information and uses the HK method for the selection of best route.

In 2011, Hlaing&Khine [5] gives a solution for TSP based on enhanced Ant Colony Optimization. They proposed an algorithm mixed with candidate list approach& dynamic upgrading of heuristic parameter of local search solution. In dynamic candidate list a number of preferred nodes are stored in a static list. When an ant moves from one node to other then it selects the node that is present in the preferred list. This strategy is used to put up searching scheme of ant colony system on bigger data. The upgrading was based on entropy &mergence of solution. From their experimental results, the proposed system is much effective in order of speed (convergence) & the ability to discovering better solutions.

In 2012, Hingrajiya et al. [6] proposed a new approach for enhancement in ACO. In the paper they proposed even distribution approachof initial ants such that there is at least oneant at each node. This makes the solutions search space larger & the chances of having best results increased. The heuristic information is used for the route selection by the ants initially. Here they use a large value of parameters of heuristic to lower the effect of pheromone so that ants can choose other paths in generating solution. It motivates them to choose closer cities which mean that they are likely to opt to travel along small edges. The paper portrays a study for prevention of stagnation& untimely convergence by using even distribution of initial ants.

B. Genetic Algorithm

In 2001, Jongsoo Kim et al. [7] portray a paper for solving TSP with precedence constraints using genetic algorithm. In this paper they used topological sort to order the vertices to be visited by the salesperson. Also they give a new crossover operator which is similar in many aspects of natural moon i.e. half-moon, full moon etc.are implemented. This crossover operator selects a random subset from population and is mixed with the selected parents to produce an offspring. The author compares their newly developed moon crossover operator with earlier operators that are OX operator and position based operator where they found that their performance is almost equivalent but the OX and position based operators do not give optimal results for the trials. However their approach is much efficient for small and mid-size problems but in case of bigger problems it gives best solution but there is no guarantee for the optimality. The one major drawback of their paper is that the topological sort they proposed for selecting vertices works only in case when the graph does not contain any cycle.

In 2012, Dwivedi et al. [8] used anindigenous search technique to increase the solution quality. In this paper they used Elitism technique for selection which initially imitates the best chromosome to newly generated population and the rest is performed in conventionalway. It can swiftly escalate the performance of GA because it avoids losing the preeminent found solution. In searching procedure a crossover location on a chromosome is defined and then SCX operator is applied to exchange the information. This newly generated crossover operator is superior in terms of cost and time as compared to traditional SCX operator. In this way a proximal optimal solution is achieved but not an optimal solution. They presented a comparative study among greedy approach, dynamic programming & genetic algorithm for solving TSP. GA seems to seek better options for TSP, and nonetheless it is dependent very much on the way the problem is described& the strategies of crossover & mutations used. They proposed a new crossover operator (SCX) which is better in terms of quality of solutions. They used a local search technique to improve the solution quality.

In 2013, Saloni Gupta et al. [9] depicted an enhanced genetic algorithm for TSP problem. In their paper they calculate the distances between various cities visited using Euclidean formula and form a matrix from the data evaluated. They work on a symmetric TSP i.e. the distance between two cities is same in both orders while moving from city a to city b and vice versa. They generated an initial population randomly and then assign them a fitness value which is taken as the distance between the cities. After this they applied the tournament selection for selecting best population from the given set and applied two-point crossover method combining the knowledge from heuristic methods & GA for solving the TSP. Finally interchange mutation is implemented for generating new population. It appears to find better solutions for symmetric TSP but it is not much efficient for asymmetric problems.

C. **Particle Swarm Optimization**

In 2007, X. H. Shi et al.[10] presented an algorithm based on novel particle swarm optimization for TSP. An undetermined searching approach & a crossover elimination method are used to increase the speed of convergence when compared with the predominant algorithms for solving TSP using swarm intelligence; it has been proven that the problems with large size can be solved with presented algorithm. Moreoverthe generalized chromosome techniqueis used to further extend the algorithm.

In 2010, Huilian Fan [11] had presented a hybrid discrete PSOalgorithm that addsadaptive disruption factor,reversion operator and heuristic factor, into the approach. In the work he implemented an update mechanism for kinetic equations to improve the efficiency of particle swarm optimization (PSO). Here they use heuristic factor for search operations i.e. to find a better route and adds reversion mutant for swapping between the paths and correlates it with noise

factor. This adaptation increases the efficiency considerably irrespective of the convergence velocity or accuracy.
In 2012, Xuesong Yan et al. [12] proposed a new PSO algorithm which overcomes the drawbacks of GA like premature convergence i.e. giving suboptimal solution.They mixes the three approaches i.e.PSO-GA-ACO and makes a 2-stage hybrid swarm intelligence optimization algorithm which offers a better and much efficient solution to TSP problem.]

CONCLUSION AND FUTURE WORK

After considering various research papers for solving TSP we can say that the heuristic algorithms (GA, ACO, PSO etc.) are proved to be much efficient algorithms than the conventional ones (like dynamic programming, greedy algorithm, branch and bound methods etc.). Even though heuristic algorithms are better but these approaches also lacks in providing the optimal solution for bigger TSP problems. These are efficient for small and mid-sized problems. There are certain issues with these also that are confinement to sub-optimal solution only like stagnation behavior in case of ACO, premature convergence in case of GA and convergence speed in case of PSO. From the beginning of these approaches a lot of amendments are done for improving their performance such as different – 2 selection, mutation, crossover strategies are given from time to time in order to improve GA. Different updating mechanisms and route selection mechanisms and adding memories in ants are implemented for the enhancement in ACO as well as in PSO. But still there is a lot of work to do for betterment of these algorithms. We can improve them by introducing well hybrid approaches i.e. introduce new operators or merge existing ones.

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