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SUBTOUR REVERSAL APPROACH IN OBTAINING LOCAL OPTIMUM SOLUTION FOR TRAVELLING SALESMAN PROBLEM

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ABSTRACT

The growing need for profit maximization and cost minimization has never been greater in human history than what we have today. This need has made optimization a very favored area of scientific investigations. This development has led to the design of a number of optimization algorithms. The Travelling Salesman Problem (TSP) is one such very important problem in Computer Science and Operations Research (OR). Quiet good numberofapproaches is available to solve TSP. Over here we have implemented Heuristic approach specifically sub-tour reversal to find local optimum solution.

Keywords –algorithms, heuristic, optimization, travelling Salesman problem

I. INTRODUCTION

Travelling Salesman Problem (TSP) is NP- hard problem in combinatorial optimization, important in operation research and theoretical computer science.[1]

Travelling Salesman Problem can be represented by complete graph G=(V,E,dij) with V represents nodes (city), E represents edge, path between two nodes and dij represents distance between node i and j. TSP is used to find complete closed shortest path which by visiting all the cities.

Travelling salesman problem (TSP) is a well-known, popular and extensively studied problem in the field of combinatorial optimization and attracts computer scientists, mathematicians and others. Its statement is deceptively simple, but yet it remains one of the most challenging problems in operational research. It is also an optimization problem of finding a shortest closed tour that visits all the given cities. It is known as a classical NP-complete problem, which has extremely large search spaces and is very difficult to solve.

The definition of a TSP is: given Ncities, if a salesman starting from his home city is to visit each city exactly once and then return back home, find the order of a tour such that the total distances (cost) traveled is Minimum. Cost can be distance, time, money, energy, etc. TSP is an NP-hard problem and researchers especially mathematicians and scientists have been studying to develop efficient solving methods since 1950's as it is so easy to describe and so difficult to solve. Graph theory defines the problem as finding the Hamiltonian cycle with the least weight for a given complete weighted graph. The travelling salesman problem is widespread in engineering applications. It has been employed in designing hardware devices and radio electronic devices, in communications, in the architecture of computational networks, etc. In addition, some industrial problems such as machine scheduling, cellular manufacturing and frequency assignment problems can be formulated as a TSP

II. APPROACHES

There have been several types of approaches taken to solving the TSP. They include:

- Heuristic approaches [3,4]
- Memetic algorithms [5,6]
- Ant colony optimizations [7, 8]

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- Simulated annealing [3, 9]
- Genetic algorithms [10, 11]
- Neural networks [4]

And various other methods for more specific variations of the TSP

These approaches do not always find the true optimal solution. Instead, they will often consistently find good solutions to the problem. These good solutions are typically considered to be good enough simply because they are the best that can be found in a reasonable amount of time. Therefore, optimization often takes the role of finding the best solution possible in a reasonable amount of time. [3] discussed about a project, in this project an automatic meter reading system is designed using GSM Technology. The embedded micro controller is interfaced with the GSM Module. This setup is fitted in home. The energy meter is attached to the micro controller. This controller reads the data from the meter output and transfers that data to GSM Module through the serial port. The embedded micro controller has the knowledge of sending message to the system through the GSM module. Another system is placed in EB office, which is the authority office. When they send "unit request" to the microcontroller which is placed in home. Then the unit value is sent to the EB office PC through GSM module. According to the readings, the authority officer will send the information about the bill to the customer. If the customer doesn't pay bill on-time, the power supply to the corresponding home power unit is cut, by sending the command through to the microcontroller. Once the payment of bill is done the power supply is given to the customer. Power management concept is introduced, in which during the restriction mode only limited amount of power supply can be used by the customer.

III. META-HEURISTICS

A **heuristic method** is a procedure that is likely to discover a very good feasible solution, but not necessarily an optimal solution, for the specific problem being considered. No guarantee can be given about the quality of the solution obtained, but a well-designed heuristic method usually can provide a solution that is at least nearly optimal (or conclude that no such solutions exist). The procedure also should be sufficiently efficient to deal with very large problems. The procedure often is a full-fledged ***iterative algorithm***,whereiterationinvolves conducting a search for a new solution that might be better than the best solution found previously. When the algorithm is terminated after a reasonable time, the solution it provides is the best one that was found during any iteration. Heuristic methods often are based on relatively simple common-sense ideas for how to search for a good solution. These ideas need to be carefully tailored to fit the specific problem of interest. Thus, heuristic methods tend to be ad hoc in nature. That is, each method usually is designed to fit a specific problem type rather than a variety of applications.

For many years, this meant that an OR team would need to start from scratch to develop a heuristic method to fit the problem at hand, whenever an algorithm for finding an optimal solution was not available. This all has changed in relatively recent years with the development of powerful meta-heuristics. A **meta-heuristic** is a general solution method that provides both a general structure and strategy guidelines for developing a specific heuristic method to fit a particular kind of problem. Meta-heuristics have become one ofthe most important techniques in the toolkit of OR practitioners.

IV. HEURISTICSAPPROACH

Here in this paper we have implemented sub tour reversal algorithm to obtain local optimal solution. Sometimes the local optimum may turn out to be global optimal solution. A **sub-tour reversal** adjusts the sequence of cities visited in the current trial solution by selecting a subsequence of the cities and simply reversing the order in which that subsequence of cities is visited. (The subsequence being reversed can consist of as few as two cities, but also can have more.) The difficulty of travelling salesman problem increases rapidly as the number of cities increases. For a problem with n cities and a link between every pair of cities, the number of feasible routes to be considered is $(n - 1)!/2$ since there are $(n - 1)$ possibilities for the first city after the home city, $(n - 2)$ possibilities for the next city, and so forth. Thus, while a 10-city travelling salesman problem has 1,81,440 feasible solutions to be considered, a 20-city problem has roughly 10^{16} feasible solutions, while a 50-city problem has about 10^{62}.

Surprisingly, powerful algorithms have succeeded in solving to optimality certain huge traveling salesman problems with many hundreds (or even thousands) of cities. However, because of the enormous difficulty of solving large travelling salesman problems, heuristic methods guided by meta-heuristics continue to be a popular way of addressing such problems. These heuristic methods commonly involve generating a

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sequence of feasible trial solutions, where each new trial solution is obtained by making a certain type of small adjustment in the current trial solution. Several methods have been suggested for how to adjust the current trial solution. Because of its ease of implementation, one popular method uses the following type of adjustment.

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V. IMPLEMENTATION

Let us consider the following instance of TSP

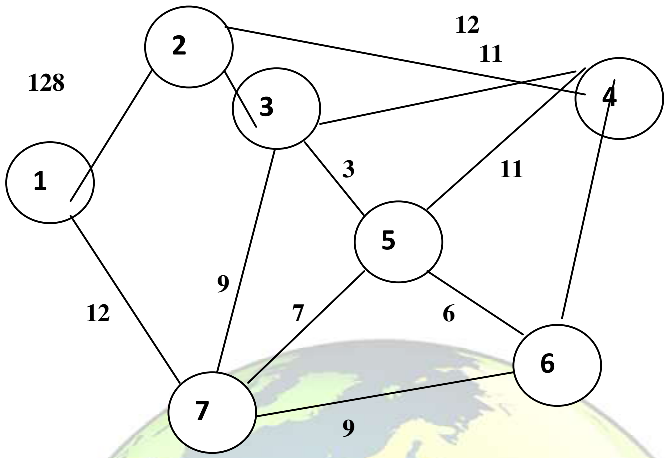

Figure 1: Original instance of TSP

The Sub-Tour Reversal Algorithm
1) Initialization: Start with any feasible tour as the initial trial solution.
2) Iteration: For the current trial solution, consider all possible ways of performing a sub-tour reversal (except exclude the reversal of the entire tour). Select the one that provides the largest decrease in the distance travelled to be the new trial solution. (Ties may bebroken arbitrarily.)
3) Stopping rule: Stop when no sub-tour reversal will improve the current trial solution. Accept this solution as the final solution.
Now let us apply this algorithm to the example
Initially we consider the cities in the increasing order. i.e **1-2-3-4-5-6-7-1**
If we traverse in this route the solution obtained will be 12+8+11+11+6+9+12 = 69

Depicted below

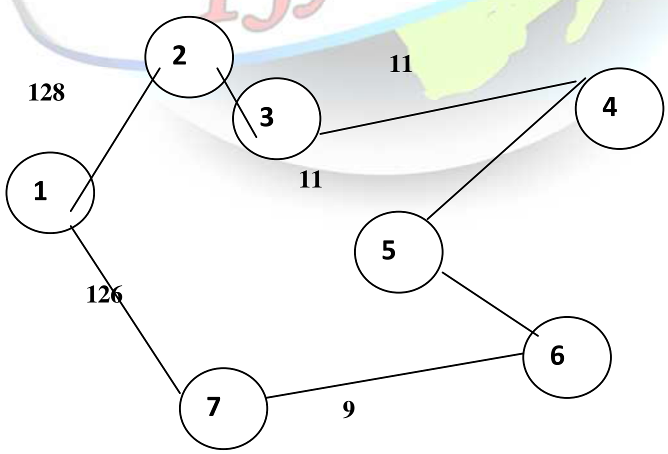

Figure 2: Initial feasible solution

This is initial trial solution. We now consider all possible ways of sub tour reversal.

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Original route:	1-2-3-4-5-6-7-1	with cost = 69
Reverse 2-3:	1-3-2-4-5-6-7-1	with cost = 68
Reverse 3-4:	1-2-4-3-5-6-7-1	with cost = 65
Reverse 4-5:	1-2-3-5-4-6-7-1	with cost = 65
Reverse 5-6:	1-2-3-4-6-5-7-1	with cost = 66

The two solutions with distance 65 tie for providing the largest decrease in the distance travelled, so suppose that the first of these, 1-2-4-3-5-6-7-1 (as shown below), is chosen arbitrarily to be the next trial solution.

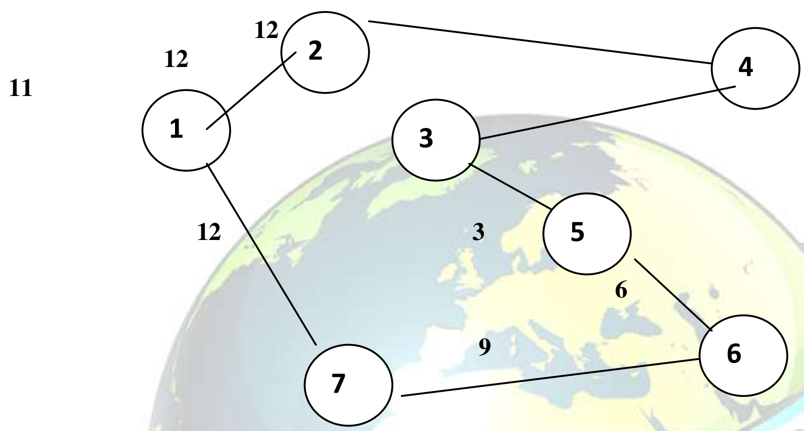

Figure 3: First sub tour reversal

This completes the first iteration.The second iteration begins with the tour of figure 3 as the current trial solution. For this solution, there is only one sub-tour reversal that will provide an improvement,as listed in the second row below:

Original route:	1-2-4-3-5-6-7-1	with cost = 65
Reverse 3-5-6-1:	1-2-4-6-5-3-7-1	with cost = 64

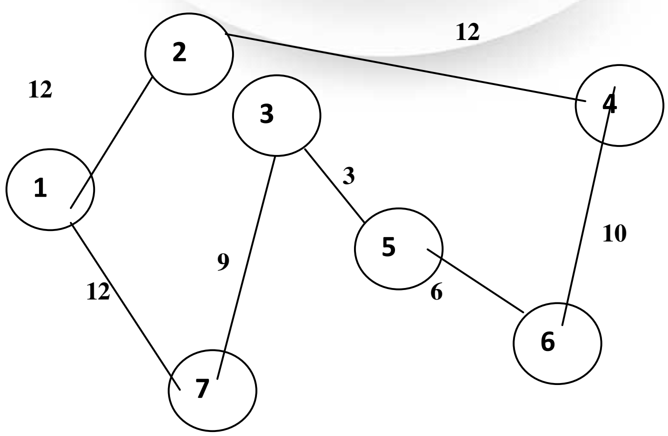

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Figure 4: Improved solution of TSP

Figure above shows this sub-tour reversal, where the entire subsequence of cities 3-5-6 onthe left now is visited in reverse order (6-5-3) on the right. Thus, the tour on the right nowtraverses the link 4-6 instead of 4-3, as well as the link 3-7 instead of 6-7, in order to usethe reverse order 6-5-3 between cities 4 and 7. This completes the second iteration.

We next try to find a sub-tour reversal that will improve upon this new trial solution. However, there is none, so the sub-tour reversal algorithm stops with this trial solution as the final solution. Is 1-2-4-6-5-3-7-1 the optimal solution? **Unfortunately NO**The optimal solution turns out to be 1-2-4-6-7-5-3-1 Distance 63(or 1-3-5-7-6-4-2-1 by reversing the direction of this entire tour)

However, this solution cannot be reached by performing a sub-tour reversal that improves 1-2-4-6-5-3-7-1. The sub-tour reversal algorithm is another example of a ***local improvement procedure*.** It improves upon the current trial solution at each iteration. When it can no longer find a better solution, it stops because the current trial solution is a local optimum. In this case, 1-2-4-6-5-3-7-1 is indeed a ***local optimum***because there is no better solution within its local neighborhood that can be reached by performing a sub-tour reversal.

VI. CONCLUSION

TSP is a central problem in combinatorial optimization. State-of-the-art complete TSP algorithms solve instances with several thousand vertices. Construction heuristics find reasonably good solutions extremely fast. Iterated Local Search is the best-performing TSP algorithms.Due to complexity involved with exact solution approaches it is hard to solve TSP within feasible time.What is needed to provide a better chance of reaching a global optimum is to use a meta-heuristic that will enable the process to escape from a local optimum.In future by studying with greater heuristics variety, we will be implementing TABU SEARCH algorithm to solve the instance of TSP along with its time complexity.

VII. REFERENCES

[1] Wikipedia, "Travelling Salesman Problem [Online]",http://en.wikipedia.org/wiki/Travelling_salesman problem
[2] Zar Chi Su SuHlaingand May Aye Khine, "Solving Traveling Salesman Problem by Using Improved Ant Colony Optimization Algorithm ",International Journal of Information and Education Technology, Vol. 1, No. 5, December 2011
[3] Christo Ananth, Kanthimathi, Krishnammal, Jeyabala, Jothi Monika, Muthu Veni, "GSM Based Automatic Electricity Billing System", International Journal Of Advanced Research Trends In Engineering And Technology (IJARTET), Volume 2, Issue 7, July 2015, pp:16-21
[4] Lin, S., and B. W. Kernighan.(1971) "An Effective Heuristic Algorithm for the Traveling Salesman Problem."*Oper. Res.* 21, 498-516.
[5] Mascato, P., (1989) "On Evolution, Search, Optimization, Genetic Algorithms and Martial Arts : Towards Memetic Algorithms", *Caltech Concurrent Computation program* 158-79.
[6] Mühlenbein, H., (1992) "Parallel Genetic Algorithms in Combinatorial Optimization". *Computer Science and Operations Research*.441-456.
[7] Dorigo, M., V. Maniezzo& A. Colorni (1991). "The Ant System: An Autocatalytic Optimizing Process". *Technical Report No. 91-016 Revised, Politecnico di Milano, Italy*
[8] Dorigo, M. & Gambardella, L., (1997) "Ant Colonies for the Traveling Salesman Problem".*BioSystems*, 43, 73-81.
[9] Lin, F., Kao, C., & Hsu, C., (1993) "Applying the Genetic Approach to Simulated Annealing in Solving Some NP-Hard Problems". *IEEE Transactions on Systems, Man, and Cyberspace* 23, 1752-1767.
[10] Goldberg, D., *Genetic Algorithms in Search, Optimization & Machine Learning.* Addison Wesley, 1989
[11] Bonomi, E., &Lutton, J., (1984) "The N-city Traveling Salesman Problem: Statistical Mechanics and the Metropolis Algorithm". *SIAM Review*, 26 (4), 551 – 569.