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RESEARCH ARTICLE

TRAVEL WEB PLANNER: INTELLIGENT SYSTEM TO ORGANIZE TOUR FOR TRAVELLERS BASED ON HEURISTIC NETWORK APPROACH

***Hamid Sadeq Mahdi**

Department of Computer Science, University of Diyala, Basic Education College, Iraq

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ABSTRACT

It seems cleverer to look into any TSP first by learning from its historical background in order to grab the fundamentals of the task usually required in such kind of exercises. TSP problems are described shortly as easy model to understand but actually hard in solving process. Thus, simply remember that TSP under the category of [problem having more to do with the called hard-problems; they are non-polynomial based problems (i.e. No polynomial time algorithms known) in most cases. In fact, TSP initially (1800-1832) did not involve math concepts. However, despite the scarcity of direct algorithms for such TSP situations, there are still ways to solve the problem of course not to its exact required solutions but, to the (nearer/most) acceptable level. This solving process is about finding some approximation methods and the solution series labelled optimization, which are both more subject to human understanding than the machines' one, hence the need for heuristic decision in regular and hard problems. Therefore, the papers review in this article is about analysing through TSP exploration, the general algorithms or standard methods, then attempting to classify the use of each relatively to TSP domains of application, mainly based on the research literatures.

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INTRODUCTION

In domains of computer science and mathematics TSPs (The Traveling salesperson problems) are well-known for their important applications in real-life problems (e.g. Transport/traffic managements). They are said to be easier to understand than to solve (Richard *et al*., 2009), (Chetan Chauhan *et al*., 2012). Despite the hardness of their solutions procedure, some various methods are defined for some such situations by application some mathematical techniques and specific algorithms. But, most extreme cases need human particular understanding and interpretation (i.e. Heuristic analysis) in order to get to better acceptable solutions (Richard *et al*., 2009), (Chetan Chauhan *et al*., 2012). Up to recent decades many businesses and industries people got rocked by the economy crisis before getting to know how much important a good transport management could greatly help the situation (Fausto Pedro García Márquez and Marta Ramos Martín Nieto, 2013).

****Corresponding author: Hamid Sadeq Mahdi,***
Department of Computer Science, University of Diyala, Basic Education College, Iraq.

TSP Brief Presentation

What about TSP? What Problem in TSP?

A TSP issue is about finding on a region (or travel system) routes' map the location of a service requesters along with the proper order of possibly visiting all of them. And that is all as the basic problem of TSP Richard *et al*., 2009; Chetan Chauhan *et al*., 2012; Papadimitriou and Steiglitz, 1978; Fausto Pedro García Márquez and Marta Ramos Martín Nieto, 2013).

TSP Concerns

Finding out a shorter path for all above mentioned visits but, the entirely visited distance bearing minimum costs is the main objective in TSP. In addition to searching for a solution with cheapest of costs, any of each location must be visited only once (with the start and the ending point being the same) (Fausto Pedro García Márquez and Marta Ramos Martín Nieto, 2013). Obtaining optimal solutions is often not enough especially in the case of hard-NP or difficult problem with respect to a required solution quality.

Therefore, the expected effective and efficient solution here will be ensured through heuristic methods Papadimitriou and Steiglitz, 1978 (Fausto Pedro García Márquez and Marta Ramos Martín Nieto, 2013).

TSP Basic Elements

Though much information enters into consideration throughout problem and solution formulation, these are at the bottom line. These are for instance: location/city/site to visit or host of services; customer-location or visit point; beginning-point (visit orientation) and ending-point (Visits distance). Based on either solving method, additional details will be added to these for better understanding and interpretation of the solution in preparation process.

Heuristics Importance in TSP Solving Process

Heuristic method/technique refers to the one helping to learn, guiding in investigation, rather than blindly or merely applying either some formulae or algorithms (where computation is required) to get solve a problem. Conceptually, heuristic approach has to do with the maths science philosophy of solving problems by discovery on the ways and not merely applying available rules/formulae. Similarly, in computer sciences, this will have to do with using a fundamental rule in problems solving but, not necessary in full use of recommended algorithms (http://www.thefreedictionary.com/ heuristic). All these are what to think of heuristic approach in such intelligent system design; otherwise, human great sense of reasoning remains and dominate in real-time processing the main tools of decision Here are some facts on the background of Heuristics importance for contribution into TSP solving. Researchers have brought many efforts in facilitating the existing a new methods of finding solutions to TSP. Because of undeniable potentials of mathematical and computer methods for modelling, it is then normal that these tools have experienced some limitations in fairly responding to TSP falling into the category of non-deterministic cases (i.e. very difficult problems), which is an issue since several decades ago. For instance (Daniel *et al*., 1977)'s authors developed a multiple TSP (as network model which demonstrate) about such limitation under conventional method with which the case could not be solvable, if kept in the context of the original problem. And their claim ranks among many others (Fausto Pedro García Márquez and Marta Ramos Martín Nieto, 2013). In (Alberto Garcia-Diaz, 2006) work, it is about the availability of many polynomial time algorithms known as good, but unfortunately limited in producing optimal solutions in TSP. Anyhow, it is also important that under heuristics principles, decisions and choices for problem solving must seek to meet user particular interest while considering various parameters and constraints to the case (Damianos Gavalas *et al*., 2013; Rina Dechter, 1998); in the meantime, one must also be aware that heuristic techniques are classified as non-exact methods group Chetan Chauhan *et al*., 2012. This simply implies that unlike computers, they are vulnerable to mistakes like any human acts. But, the potential of selecting, applying and controlling knowledge in complicated problems solving make human expertise beyond that of any man made intelligent system (Rina Dechter, 1998).

MATERIALS AND METHODS

Algorithms or standard methods

Thanks to Chetan Chauhan *et al*., 2012 authors for one of recent survey produced on some common TSP solving methods. Their review focused mainly on screening out cases for which heuristics have failed to stand for the best as much believed in some other studies. This article under this subsection attempts to briefly discuss about TSP standard or commonly used algorithms, with a bias view on heuristics. Moreover, in the next section, some related TSP solving methods are also introduced, to further verify the position of heuristics and the role played in handling difficult TSP.

Difficult Problem in TSP Research

The theory of complexity showing TSP as being under the called NP-complete problems or simply difficult problems' group is mentioned in Papadimitriou and Steiglitz, 1978. It also conducted a study on symmetric TSP ended with an optimal solution but that could not be improved merely with some changes in k-edges—a situation's view supported in related works in the same article. Otherwise, that is another reality about local search algorithms with polynomial time complexity per iteration, bringing about approximation impossibility for such TSP solving progress (Unless P=NP) Richard *et al*., 2009; Chetan Chauhan *et al*., 2012Papadimitriou and Steiglitz, 1978.

A summary for general definition of difficult TSP is in Papadimitriou and Steiglitz, 1978 as follow.

- Suppose an instance having a very large number of local optima with respect to some neighbourhood structure N, and a unique global optimum. This is a difficult instance with respect to local search using N.
- Another case: TSP with k-change search for large values of k (e.g., k comparable to n), is a difficult instance for local search algorithms in general.
- Due to its applicability under other study fields made possible by researchers, TSP get harder to solve that its mere formulation. Some of obvious reasons are the problem inputs difference, their interpretation to the TSP standard and solution model. Hence, heuristic approach importance in providing the appropriate alternative to get ahead a given problem.

TSP Common Algorithms Standards

2.3.1 Brief Review on TSP Solving using Heuristic Method
Many important studies have discussed about heuristic algorithms applicable in TSP, which are able to produce TSP solutions nearer to optimal in distance and costs expectation (Richard *et al*., 2009) Chetan Chauhan *et al*., 2012Papadimitriou and Steiglitz, 1978(Fausto Pedro García Márquez and Marta Ramos Martín Nieto, 2013). Since past decades to nowadays, TSP helped modelling and solving various managements based problems such as in routing, facility location, tasks scheduling, travel/shipment, network design issues and many more in different science fields.

And according to (Fausto Pedro García Márquez and Marta Ramos Martín Nieto, 2013), article like Bellmore and Nemhauser (1968), Bodin (1975), Golden *et al*. (1975), Gillett and Miller (1974), and Turner *et al.* (1974) are among the great examples which provide useful literature reviews for TSP.

Example of Algorithms for TSP Solving

Hamiltonian Cycle into TSP Solving Method

Based on principle similarity, circuit or Hamiltonian cycle along the edges of a dodecahedron finding process can be seen as the original/basic algorithm of TSP, and it is originated from Icosian game—i.e. a game invented (1859) by Sir William Hamilton (Figures '1' and '2'). And that game required solution is the today's TSP basic solution —i.e. obtaining a Hamiltonian circuit or a path with every vertex visited only once, no edge can be revisited, and the ending and the starting points are the same Chetan Chauhan *et al*., 2012.

Figure 1. Icosian Game

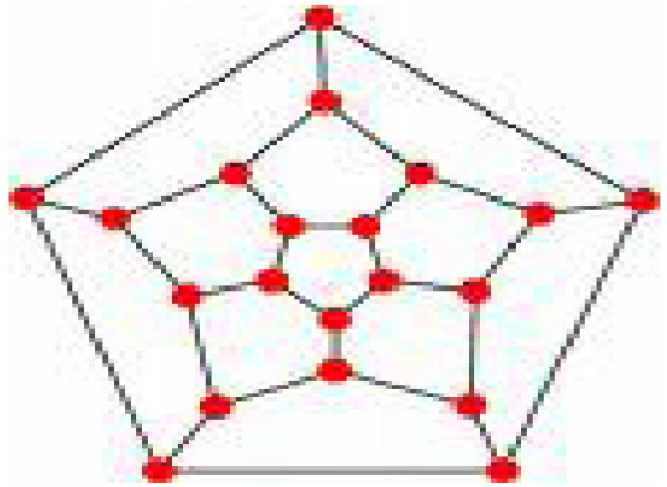

Figure 2. Dodecahedron

A clearer form for TSP was developed by 1930 by the mathematician Karl Menger, the father of brute-force algorithm and nearest neighbour heuristic. And based on this source, many people have contributed in improving TSP solving fundamental algorithm. However, almost each new improvement algorithm received its contributor name(s) and an illustrative phrase (e.g. Richard M. Karp (1972) with NP-Complete for Hamiltonian cycle; Lin and Kernighan (1973) with "Lin-Kernighan" algorithm; Bentley (1990) with the k-D tree; Lin-Kernighan heuristic algorithm (1998), called (LKH), etc.,). Overall, the pluralism of TSP solving algorithms has occurred as a reason of many attempts with different concepts even under same problems category. These are few dire about TSP solving algorithm by contributors, which in turn make up another source of TSP solving complexity. Therefore, there is a permanent need for consensus on divergent views with respect to especially difficult problems whenever alternative method is available.

ANALYSIS OF TSP SOLVING METHODS STANDARD

At Beginning

TSP (since 1950) is as old as other applied math then computers problems under Combinatorial Optimization model Chetan Chauhan *et al*., 2012. Its various solving techniques/methods have remained theoretical but, they have rendered its concept background interesting and applicable into other problems with general principle and acceptable for Discrete Optimization Problems Chetan Chauhan *et al*., 2012.

Problem Solving Basic Modelling (Formulation)

The TSP basis model consists of number (n) of cities (V) geometrically represented by a given E edge-weighted graph G, whose vertices are (V) such as,

- G = (V, E) and V is a set of n=|*V*| cities to visit*;*
- E $\subseteq$ (V*V) is a set of directed edges linking each couple of cities at (i,j) $\in$ E, with endpoints (i≠j), i $\in$ V_1 and j $\in$ V_2 such as the two cites have d_{ij} distance parameter,

Then, for each V (i,j) in the graph: TSP is either asymmetric or symmetric, meaning:

- TSP Symmetric ↔ dij=dji –i.e. any direction from which to visiting either (i) or (j) does not matter (but, yes in opposite case)
- Else, TSP Asymmetric ↔ dij≠dji –i.e. direction does matter in starting point of visits

Hence, once these conditions hold together, TSF solution can be determined using either credible method. Thus, for Chetan Chauhan *et al*., 2012 an optimal solution can be obtained in finding f(π) minimum distance through permutation π of nodes (i.e. n=|V| nodes or vertices/point referring to as cities).

Therefore, for node indices {1…, n} the path distance f(π) minimal is derived from:

$$f(\pi) = \sum_{i=1}^{n-1} d_{\pi(i)\pi(i+1)} + d_{\pi(n)\pi(1)}$$

TSP Solution Main Concern

In TSP solving process, the following three principles are very important. First is to determine the called Hamiltonian minimum length Richard *et al*., 2009; Richard *et al*., 2009; Chetan Chauhan *et al*., 2012; Papadimitriou and Steiglitz, 1978; http://en.wikipedia.org/ wiki/ Travelling_salesman_ problem, ? -- i.e. the trip closed shortest-road going only once through n nodes /cities, with less costs. Next is to find TSP optimal solution by permutation π of node indices (n). And finally, heuristic algorithm is the alternative for more difficult problems in general.

TSP Common Solving Methods

They are categorized as exact and non-exact solving techniques Chetan Chauhan *et al*., 2012; many being used like a standard method for similar problems over time.

The first group -- comprises basically of

- Linear Programming based techniques (e.g. Cutting Plane, Interior Point, Branch-and-Bound and Branch-and-Cut).
- Branch and Bound method: -lists-down every possible solutions and breaks TSP into small sets, proven efficient for network of about 60 nodes
- Cutting Plane: - applicable to all problems; uses linear programming relaxation at iterations start.
- Branch and Cut: - useful in for TSP with huge of instances
- Dynamic Programming based techniques—method involving *efficiently recurrences computations whose results are results and re-using them when needed*.
- Brute-force method—a turbo solver, as it can fit for any problem and produce the two basic required answers elements.
- Whereas the second category consists of a group of three namely: approximation, heuristics and a group of algorithms combining both approximate solutions and large running-times cases.

Heuristic method based tsp solving

Travel Based TSP Study and Analysis

In typical travel design based TSP, getting to know the participants' desires and the interesting sites/locations/cities they may like to visit – these are the primitive details of the travel network designer. However, such travel particular concerns are about determining the above inputs in a way that they can closely meet the visitors' likes at preferential costs and maximum satisfaction (Takashi Hasuike *et al*., 2014). All possible obstacles, difficulties (e.g. spatial, climatic, environmental, and social) and constraints (e.g. finance, time, logistic, gastronomic, health, and security) are other important considerations making up a tour complete costs and thus its feasibility Chetan Chauhan *et al*., 2012 (Fausto Pedro García Márquez and Marta Ramos Martín Nieto, 2013; Damianos Gavalas *et al*., 2013; Hülya Demez, 2013.

TSP Solving Techniques Category

Heuristic algorithms, based on Chetan Chauhan *et al*., 2012, fall under the category called "non-exact solvers". The other techniques group mates are "approximation algorithms" – i.e. TSP Solving Traditional Methods **(**MST based algorithm, mixed MST and Minimum Matching Problem/MMP); and a "fascinating algorithms" set (e.g. Simulated Annealing, Genetic Algorithms, Ant-Colony Algorithms and some machine learning algorithms (e.g. Neural Networks). However, heuristic algorithms produce only feasible solutions (i.e. free from too many theoretical outcomes). Two kinds to distinguish: simple tour-construction based algorithm (e.g. Nearest Neighbour, Clarke-Wright and Multiple Fragment1) and complicated tour improving algorithms based methods (e.g. Tabu Search and Lin-Kernighan).

Heuristic Methods

Here is (Table 1) a list of method's examples Chetan Chauhan *et al*., 2012(Fausto Pedro García Márquez and Marta Ramos Martín Nieto, 2013) with indications for articles (examples) in which relevant discussion can be found (Fausto Pedro García Márquez and Marta Ramos Martín Nieto, 2013).

Table 1. Example of Heuristic Methods

Heuristic Methods	Sources
Branch-and-bound	Finke *et al.* (1984); Little *et al.* (1989); Balas and Toth (1985); Miller and Pekny (1989)
2-opt	Lin and Kernighan (1973); Bianchessi and Righini (2007); Gendreau et *al*. (1999); Potvin *et al.* (1996); Tarantilis (2005); Tarantilis and Kiranoudis (2007); Verhoeven *et al.* (1995)
Insertion	Breedam (2001); Chao (2002); Daniels *et al*. (1998); Lau *et al.* (2003); Nanry and Barnes (2000)
Neural network	Shirrish *et al.* (1993); Burke (1994)
Simulated annealing	Kirkpatrick *et al.* (1985); Malek *et al.* (1989); Osman (1993)
Tabu search	Glover (1990); Gendreau *et al.* (1996); Gendreau *et al.* (1998); Ahr and Reinelt (2006); Augerat et *al*. (1998); Badeau *et al.* (1997); Brandao and Mercer (1997); Barbarosoglu and Ozgur (1999); Garcia et *al*. (1994); Semet and Taillard (1993); Hertz *et al.* (2000); Montane and Galvao (2006); Scheuerer (2006)
Exact methods	Carpaneto and Toth (1980); Fischetti and Toth (1989); Gouveia and Pires (1999); Lysgaard (1999); Wong (1980)
Genetic Algorithm	Gen and Cheng (1997); Potvin (1996); Moon *et al.* (2002)

Issues in TSP Solving

TSP Iteration and Solution Particular Principle

Based on the literatures general rules and regardless of TSP two main categories (i.e. regular or hard-NP /difficult cases), any TSP requires visiting each of v-cities only once with the last trip returning at origin city (V_1). And under this condition, the optimal solution is satisfactory with the trip shortest-distance, and the lowest-costs. Hence, these two criteria are the bottom line in TSP solving process. Furthermore, because, there are no (unique) algorithms for solving all TSP cases, heuristics concepts are likely to always be the best of reasoning references Richard *et al*., 2009; www.csd.uoc.gr/~hy583/ papers/ch11.pdf; Richard *et al*., 2009. When and where all trustfully existing techniques have collapsed failed. As bias view, that is simply due to human higher level in decisions

(appreciation) than any from the robots (computer systems in general).

Optimal versus Heuristics Solutions/Method

There are many valuable reasons Chetan Chauhan *et al*., 2012; Papadimitriou and Steiglitz, 1978; Fausto Pedro García Márquez and Marta Ramos Martín Nieto, 2013) to choose specific techniques.

- The suitability with the type of problems including the frequency in practice can be the general rule of thumb. But what justification beyond this?
- The numerous existing optimal based algorithm as presented in Chetan Chauhan *et al*., 2012 and discussed here in "2.2.2" required a good knowledge of existing algorithms and a good understanding of TSP in hand in order to pick up the right solving method.
- Another inherent cause is the extension of TSP concept for application with other problem of general principle. For, it arguable to agree on a reasonable number of visiting locations in ordinary travel system problem. But, under real-life application (e.g. mail distribution. Product distribution, assembling managements, etc.,), the number (n) theoretically grow too high up and turn down the efficiency of well-known algorithms learnt from similar problem. Therefore, heuristic can allow drawn a fair conclusion when facing such cases.
- As particular remark, Heuristically referring to TSP solving main principles, distance (or shortest-path) may not the best of consideration if only in terms of its cost (though direct path is known a minimizing cost), but instead for significant shipment (i.e. true sign of service effectiveness) involved (Fausto Pedro García Márquez and Marta Ramos Martín Nieto, 2013).

General conclusions

This review attempted initially to go through some selected articles for TSP general rules and especially those about problems solving methods. The lessons from those sources have provided some good insights in understanding and differentiating between optimal and heuristics methods. In concluding points, here some consideration for motivation to learners and researchers interested in TSP based studies in general and in particular on intelligent systems design for a tour activity management using heuristic methods. And for TSP solving, few recalls about heuristics usefulness were reported in introduction of this review. They were more a reminder; the other sections have also proved that one must develop an interest on heuristic based algorithms and their development for better handling of TSP difficult problems.

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