Water Flow Algorithm Decision Support Tool for Travelling Salesman Problem

Anis Aklima Kamarudin[a)], Zulaiha Ali Othman[b)], and Hafiz Mohd Sarim [c)]

Universiti Kebangsaan Malaysia, 43600 Bangi, Selangor, Malaysia.

[a)]Corresponding author: anisaklima@yahoo.com
[b)]zao@ukm.edu.my
[c)]hms@ukm.edu.my

Abstract. This paper discuss about the role of Decision Support Tool in Travelling Salesman Problem (TSP) for helping the researchers who doing research in same area will get the better result from the proposed algorithm. A study has been conducted and Rapid Application Development (RAD) model has been use as a methodology which includes requirement planning, user design, construction and cutover. Water Flow Algorithm (WFA) with initialization technique improvement is used as the proposed algorithm in this study for evaluating effectiveness against TSP cases. For DST evaluation will go through usability testing conducted on system use, quality of information, quality of interface and overall satisfaction. Evaluation is needed for determine whether this tool can assists user in making a decision to solve TSP problems with the proposed algorithm or not. Some statistical result shown the ability of this tool in term of helping researchers to conduct the experiments on the WFA with improvements TSP initialization.

INTRODUCTION

With the rapid development of world economy, the rise to a vast consumption of good while globalization has led to large amount of goods transportation all over the world. Therefore, reducing the transport costs for transportation company is in demand. There are various methods to reduce cost, one of the method is to find the shorter route known as Travelling Salesman Problem. TSP is combinatorial optimization problems that are common in operations research [1][2]. This problem is triggered when the salesman must go to each city in one tour only to save the cost and time.

Decision Support System (DSS) is capabilities of the computer to improve the decision making. Decision Support Tool (DST) is a particular kind of DSS as analysis tool that can be used to help decision maker support their decision making and analyse the situation or issue and improve the process of strategic information or selected management. The software can be used as reference to the user to decide using visualize the TSP. in the common sense, a system is many parts that all make up a whole, it has structure, behaviours and all have to work together. DSS are computer-based systems that support individual or organizational decision-making activities [3]. The DST was developed to help users to run experiments on the algorithm proposed, by modifying the configuration of the algorithm to see the important effect of the changing parameters toward on the result.

In order to optimize the solution of TSP, Water Flow Algorithm (WFA) that has been proposed by [4] will make some improvement of initialization technique. WFA is a very sensible way could be used now days by the study [5]. This is due to the behaviour of liquid flow in the design of the solution search. Improvements at the initial stage can help to achieve the optimization as well increase of computing time and simplify sort the data for early stage before further processing takes place.

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Therefore, the DST will display each parameter that have to set by the user to see the effectiveness of the WFA. DST will also visualizes the movement of TSP for the purpose of understanding the user to show the results of the algorithm works. The results generated will show the suggestion decision for TSP distance of dataset.

Section 2 in this paper provides a literature review on state of the art of Decision Support System, TSP problem and metaheuristic algorithm. Section 3 discuss about the method used in this study and the implementation of the method. Section 4 describes the findings from the method's implementation, with some chart and figure that can be refer. The last section is the summary of this paper and future work.

2. LITERATURE REVIEW

Decision Support Tool has been widely adopted in the model of artificial intelligence to optimize complex problems such as scheduling [6], planning [7] and traffic at the city [8]. It also developed to solve complex problems to get the optimum value. [9] using Simulated Annealing for searching economic benefit to the maximum. [10] has been using mathematical models with heuristic methods to optimize the steel cutting issues while [7] was proposed metaheuristic based intelligent decision support system for plant optimization.

For the TSP problem, there have still lacking of the study that emphasizes on development of DST as a main point on their study. Only a few number of researchers focused toward DST for demonstrate the uses of the proposed algorithm. Most of them only focused on finding the best algorithm for optimization compared visualize to the user. [11] using Genetic algorithm to solve the TSP problem and visualize in interactive that recommended. [12] develop an animation for TSP problem using backtracking and branch and bond while, an interactive simulation and analysis software for TSP using Ant Colony algorithm that has been proposed by [13].

There are some efforts that have been made in the domain of artificial intelligence that aims to find the best solution of TSP. there are two basic approaches, either exactly or approximately, the approach is not sufficient to solve the problem especially for solving a very large space. In literature review has shown that the most popular approach used to solve the TSP is metaheuristic algorithms. Metaheuristic is a general algorithm framework that was designed for solving combinatorial optimization problems (COP). Several of metaheuristic algorithm have been applied in TSP. the most popular algorithm that always been use are ACO [14], Genetic algorithm [15], Simulated Annealing [16], Tabu Search [17].

Water Flow Algorithm (WFA) were categorized as metaheuristic algorithm for solving COP. For travelling Salesman Problem (TSP), WFA has been tested with population agents to prove the efficiency in dealing TSP problem [5]. However, WFA method still requires improvement in terms of computing time. Therefore, improvements in terms of initialization technique has been proposed using Simulated Annealing (SA). According to study [18] SA takes shorter time than a comparable algorithm. This indicates that SA is effective algorithm in helping optimization.

3. METHODOLOGY

The selection of strategy to solve the TSP problem to obtain optimal results by dynamically changing solution-based agile method to conduct an efficient and effective solution search. This new algorithm [5] using dynamic population based-metaheuristic algorithm. Some of researcher do not focus on initialization part. In previous works shown that initialization also can give effect to algorithm process especially in computing time.

In order to assess the performance of the proposed algorithm with original WFA for TSP [5], it must ensure all approaches were run in the same computing environment and especially the power of hardware must be same. Because it might affect the computation time for algorithm. The implementation that have been done by [5] was re-run on the same computing environment also. To get effective and reliable experiment result, the experimental setting should be the same with [5]. Solution quality and computation time could be impacted by different parameter settings.

The methodology used in this study is Rapid Application Development (RAD) model by [19] represent the general software development model in this research. RAD using a prototype technique that has been establish and tools to produce software applications. It covers the development environment graphical user interface, which allows end user to easily use the software application components. The model consist of 4 phases. Requirements planning, User design, Construction and Cutover.

4. ANALYSIS

The basic evaluation of algorithm is performed by making comparison between the proposed algorithm with [5] WFA-TSP based on solution quality and where the computation time is within 10 times independent operation with 10,000 iteration to obtain the best operations. Doing Statistics test with Microsoft Excel 2013 includes descriptive statistics adopted by [5] work which is mean, standard deviation, best solution, average, computation time, average of iteration, percentage deviations of the average best known solution, improvement percentage and average computation time.

However, in order to evaluate DST, it was conducted through questionnaires for usability test proposed by [19], based on system usefulness, information quality, interface quality, and overall satisfaction factors. Evaluation is not only used to describe the outcomes and results only, but will also strengthen and improve implementation. In this study, the usability test will evaluate the DST within 6 steps and will completed by 10 respondent that have IT background.

4.1 Finding from the questionnaire

4.1.1 Analysis of the question on System Usefulness

From the preliminary analysis, it seems that all respondent know the concept of TSP problem. When they tested on the tools, it shown there have a few of function and parameter setting that can be used to see the differences and the performance of the algorithm proposed. So they can tested on which parameter as they wants as shown in Fig. 1.

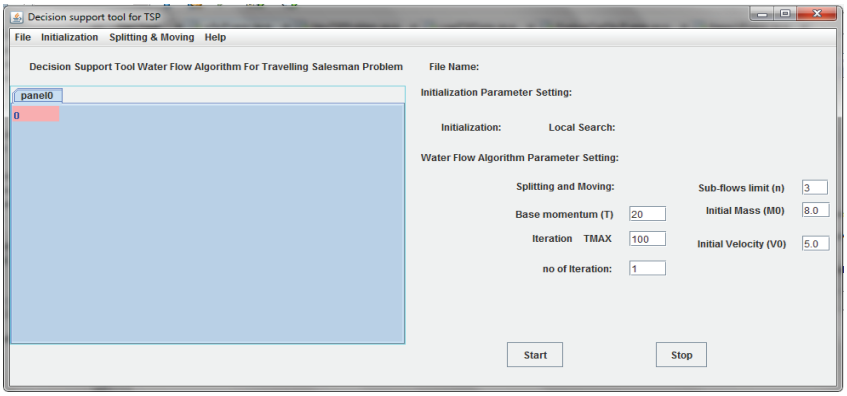

FIGURE 1. Interface of the system

In initialization, the user can set the parameter setting of Simulated Annealing to the effect of this algorithm process. For splitting and moving part, there also have 3 option of local search which is using 2-opt, 3-opt, and 4-opt.

From the analysis, it shown that the result implicates that the respondents are satisfied with the system usefulness. From the questionnaire, two respondent stated that the proposed system is easy to learn and understand while one respondent mentioned that this system is both effective and efficient.

4.1.2 Analysis from the question on Information Quality

System will process the data and the parameters entered by the respondent and generate the result. System will suggested visualized result of the prototype is shown in Fig 2 and will show the best solution length and the city connection is shown in the panel on the left side.

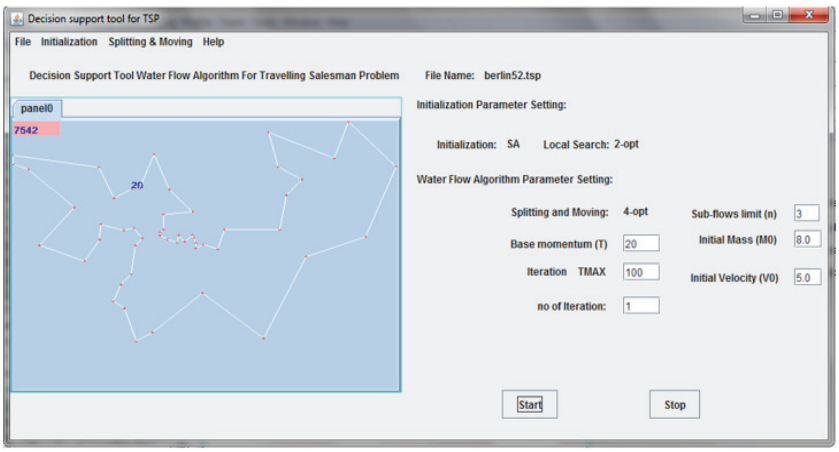

FIGURE 2. Visualized TSP Solution

Besides that, city 20 is the starting point of the solution. The result will show in document format. This document covered the detail information of dataset launched for testing, the best solution found in iteration, time taken for the best solution found, the length of the best solution found, and the city sequence for the best solution found. Analysis shows that the respondent are satisfied with the information quality. Two respondents stated that the user manual and help information provided are good while one respondent found the recommend suggestion as east for user.

4.1.3 Analysis from the question on Interface Quality

From the analysis result, interface quality show satisfactory performance. It shows that user are satisfied with interface design featured on this system. Three respondents stated that the design interface have features user-friendly and easy to understand. There are many function that can be change like open file function, user can change the data selected for test the efficiency. User also can create a new file to use their own data and will stored as an input for next process.

4.1.4 Analysis from the question on Overall Satisfaction

Fig. 3 shows the comparison with all factors in term of the mean. From this analysis we can see how the performance of the system in applying the algorithm proposed to the user. This result proves that respondents are satisfied with the overall satisfaction.

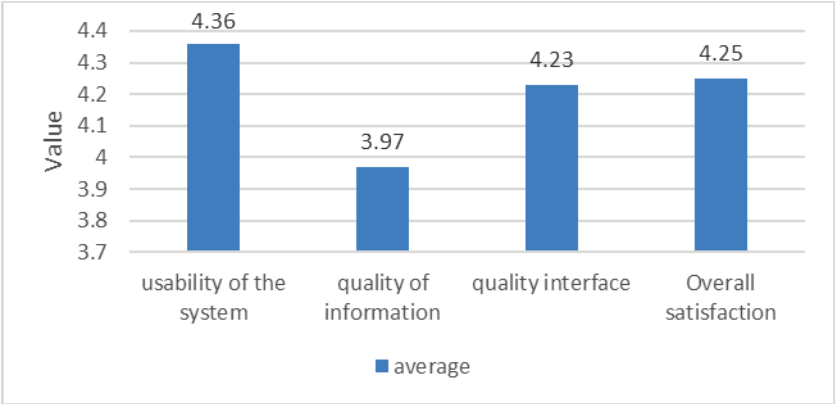

FIGURE 3. System Evaluation Score

5. CONCLUSION AND FUTURE WORKS

As a conclusion, Decision Support Tool (DST) for TSP prototype has also been successfully developed using algorithm that have been adopted from [5] and improve the initialization technique. Simulated Annealing that have used in initialization prove that it can affect the process of algorithm and can give more good result to the user. DST allowed the researchers to make an experiment by adjusting all the parameter value to see the performance to obtain TSP solution. The usability test evaluation show that the tools get a good feedback from the respondents. For the future works, it can be continue by adding more algorithm in this tools, so the research on TSP can use function and can make comparison between each other more is better.

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REFERENCES

1. E. Lawler, J. Lenstra, A. Rinnooy, D. Shinmoys. *The Traveling Salesman Problem*. John Whiley & Sons, **vol. 25**, no. 4, pp.251-258, (2006).
2. G. Gutin, A. Punnen. *The Traveling Salesman Problem and Its Variations.* Dordrecht: Kluwer, **vol. 35**, no. 2, pp.625-629, 2002.
3. Guisseppi A. Forgionne, "An architecture for the integration of decision making support functionalities", in Decision Making Support Systems: Achievements, Trends and Challenges for the New Decade, Manuel Mora, Guisseppi A. Forgionne, Jatinder N.D. Gupta, (Eds), Idea Group Inc, pp.1-19, (2002).
4. Yang, F.-C & Y.-P. Wang 2007. Water flow-like algorithm for object grouping problems. Journal Of The Chinese Institute Of Industrial Engineering 24(6) : 475-488
5. Ayman S.H., Zulaiha A.O. & Abdul R.H. A Water Flow-Like- Algorithm for the Travelling Salesman Problem. *Advances in Computer Engineering* (2014).
6. Abdelkghany, K.F., A.F. Abdelghany & G.Ekollu. An intergrated decision support tool for airlines schedule recovery during irregular operations. *European journal of Operational Research 185(2):* 825-848 (2008)
7. Adekanmbi, O. & P.Green. A Meteheuristic Based Decision Support System for Optimal Crop Planning. *Mediterranean Journal of Social Science* 5(20):359 (2014)
8. Ma, Z.., H. Wang, A.Wu, G.Zeng & X.Tu. An intelligent decision support system for residential energy consumption and renewable energy utilization in rural China. *Energy Sources, Part B: Economics, Planning, and Policy* 9 (4):374-384. (2014)
9. Zhao, J.Y., Zhang, T.J. & Sun, R.F. Crop Planting Decision Supporting System Based on Simulated Annealing Algorithm. *Electrical and Control Engineering (ICECE), 2010 International Conference* on. Pp.2711-2714.(2010)
10. Perng, C., S-J. Weng, J-Tsai & B.-C.Jheng. A two phase decision support system for optimizing the steel roll cutting problem. Techonolgy Management In The Energy Smart World (PICMET), 2011 *Proceeding of PICMET'11*: .pp. 1-7 (2011)
11. Ugur, A. & D. Aydin. An interactive simulation and analysis software for solving TSP using Ant Colony Optimization algorithms. *Advances in Engineering software* 40 (5); 341-349.(2009)
12. Dorigo, M. &L. M. Gambardella. At colony system: a cooperative learning approach to the travelling salesman problem. *Evolutionary Computation, IEEE Transactions on* 1 (1):53-66.(1997)
13. Goldberg, D.E. 1990. E.Genetic algorithm in search, optimization and machine learning. *Reading: Addison-Wesley*. (1989).
14. Martin,O, C. & S.W.Otto. Combining simulated annealing with local search heuristic. Annals of Operations Research 63 (1): 57-75.(1996)
15. Glover, F. Tabu search-part 1. ORSA *Journal on Computing* 1(3); 533-549 (1989)

16. M. Banka, S.M.T. Fatemi Ghomia, F. Jolai & J. Behnamiana. Application of particle swarm optimization and simulated annealing algorithms in flow shop scheduling problem under linear deterioration, *Advances in Engineering Software* 47 (2012) 1–6. (2012)
17. Martin, J. *Rapid application development* Ed: Macmillin Publishing Co., Inc. (1991)
18. Hosny, M.I. *Investigating heuristic and metaheuristic algorithm for solving pickup and delivery problems*. Tesis Cardiff University, (2010)
19. Lewis, J.R. IBM computer usability satisfaction questionnaires: psychometric evaluation and instructions for use. *International Journal Of Human-Computer Interaction* 7(1): 57-78. (1995)