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S-Metaheuristics Approach to Solve Traveling Salesman Problem

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Abstract

Metaheuristic algorithm is a state of the art optimization method which suitable for solving large and complex problem. Single solution technique – S-metaheuristic is one of metaheuristic algorithm that search near optimal solution and known as exploitation based. The research conducted to seek a better solution for deliverying goods to 29 destinations by comparing two well known optimization methods that can produce the shortest distance: Simulated Annealing (SA) and Tabu Search (TS). The result shows that TS – 107 KM has a shorter distance than SA – 119 KM. Exploration based method should be conducted for next research to produce information in which one is a better method.

1. INTRODUCTION

Nowadays, almost all profit oriented organizations are trying to lean the usage of resources efficiently and effectively, especially during the covid-19 pandemic. To be efficient and effective organization, all employees must hand in hand to shape and to reach the goals. The sectors to be efficient and effective cover inventory, transportation, production, utilities such as electricity, water, gas, communication, and human resource allocation. Transportation as one of the potential resources to be leaned, must be paid attention by organization. One must design a route plan in order to achieve efficient fuel usage and faster delivery to customer by choosing the shortest route. Once fuel usage decreased and energy usage will be decreasing too and accelerate greener environment (Dukic et al., 2010; Chandra and Setiawan, 2019).

There are two types of optimization methods, one is exact method and the other one is approximate method. Approximate method generates high quality solutions in a reasonable time for practical use but there is no guarantee of finding a global optimal solution. One of the algorithms is metaheuristics which has two contradictory criteria: (i) exploration (population based – ant colony, bee colony, evolutionary algorithm, particle swarm, genetic, etc) and (ii) exploitation (single solution based – simulated annealing, tabu search, local search, etc.).

Single solution based metaheuristics is coded with S-metaheuristics and population based metaheuristics is coded with P-metaheuristics. Metaheuristic as a state of the art optimization algorithm is used when the problem is large and complex. (Talbi, 2009). Metaheuristics method is relevant in the context of solving search and optimization problems and describes a method that uses one or more heuristics and inherits all the three properties: (i) seeks to find a near optimal solution, (ii) usually has no rigorous proof of convergence to the optimal solution, and (iii) is usually computationally faster than exhaustive search (Luke, 2016).

In this paper, the well known S-metaheuristics method: tabu search and simulated annealing were compared to solve traveling salesman problem in 29 destinations of food and beverage outlets where located in Jakarta where nowadays, the management does not have the fixed method to use. The goal is to find the shortest route in deliverying goods to all destinations.

2. RESEARCH METHODOLOGY

The study compared the two methods of S-metaheuristics which each method claimed to produce the shortest distance. This study does not consider the loading and unloading time, queueing time in loading dock, and waiting time. The study only compare the distance of visiting all destinations by two single solution algorithm: tabu search and simulated annealing.

The assumptions of this research are the following:

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a. The distance of forward and backward between two destinations is the same, in other words, the case is symmetric traveling salesman problem.
b. There is no traffic jam when deliverying goods.
c. Every destination is only visited once by a truck.

2.1 Tabu search algoritm

Tabu search proposed by Fred Glover in 1986. The word of tabu comes from Tongan, a language of Polynesia, where it was used by the aborigines of Tonga island to indicate the things that can not be touched because of they are sacred (Glover and Laguna, 1997). Tabu search is a metaheuristic that guides a local heuristic search procedure to explore the solution space beyond local optimality. Tabu search has succeeded in finding improved solutions to problems in scheduling, sequencing, resource allocation, investment planning, telecommunications, and many other areas (Glover, 1994). The basic principle is to pursue local search whenever it encounters a local optimum by allowing non improving moves and cycling back is prevented by tabu list that record the recent history of the search, a key idea that can be linked to Artificial Intelligence concepts (Gendreau, 2002). Tabu search explore more solutions from the feasible region (Alkallak and Sha'ban, 2008).

The pseudocode of tabu search is as follows (Hindsberger and Vidal., 2000):

Begin
Choose initial solution, $x \epsilon S$
$x^* := x$
$C^* := C(x)$
$k := 0$
choose $V \subseteq N(x, k)$
$y^* := min \{C(y) \mid y \epsilon V\}$
while not stop do
$x := y^*$
if $C(x) \leq C^*$ then
$x^* := x$
$C^* := C(x^*)$
Endif
$k := k+1$
update $N(x, k)$
choose $V \subseteq N(x, k)$
$y^* := min \{C(y) \mid y \epsilon V\}$
end
end

2.2 Simulated annealing algoritm

Simulated annealing is a method for finding a good (not neccessarily perfect) solution to an optimization problem. If you are in a situation where you want to maximize of minimize something, your problem can likely be tackled with simulated annealing. Simulated annealing's strength is that it avoid getting caught at local maxima solutions that are better than any others nearby, but are not the very best (Geltman, K.E., 2014). Simulated Annealing (SA) is motivated by an analogy to annealing in solids and SA is a local search algorithm (Eglese, 1990) and as a three common heuristics technique (De Weck, 2010). The idea of SA comes from a paper published by Metropolis et al. (1953). The following algorithm - pseudocode is taken from Russell and Norvig (1995), although we can find similar algorithms in many of the other text books mentioned in the course introduction, as well as in the references at the end of this material, but the concept is the same.

2.3 Instrument

MATLAB software is used to solve the problems in this research. The name MATLAB stands for MATrix LABoratory and written originally to proved easy access to matrix software developed by the LINPACK (Linear System Package) and EISPACK (Eigen System Package) projects. MATLAB is a high performance language for technical computing, it integrates computation, visualization and programming enivironment and a modern programming language environment. MATLAB has sophicated data structure, containes built-in editing and debugging tools and supports object oriented programming, and these factors make MATLAB and excellent tool for teaching and research (Houcque, 2005; Attaway, 2009). Computer specification for running the program code is MATLAB 2015a, Intel Core i5 7200 U CPU 2.5 GHz, 32 bit ACPI x64 based PC.

2.4 Research framework

Data that needed for this study are coordinates of locations and distance in kilometers for 29 destinations. Then after that, the data is inserted in MATLAB program and runned to get the results. The framework is in this Figure 1.

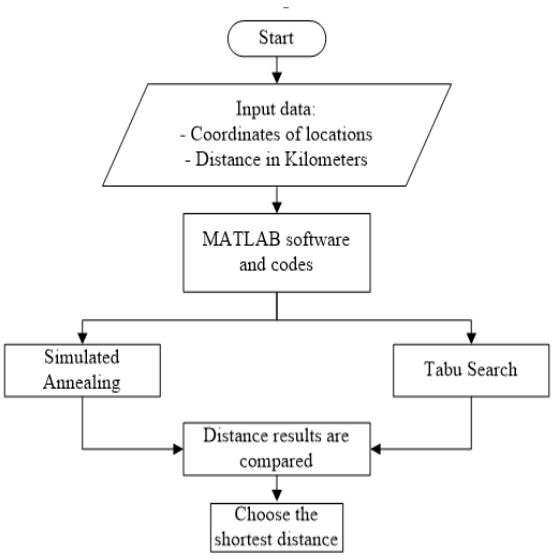

Figure 1.
Research Framework

3. RESULTS AND ANALYSIS

After inserting the distance data and running the MATLAB for both algorithm - SA and TS, the results are presented in Figure 2. The total distance indicated in Figure 2 is 119 Kilometer and the processed time is 33.78 seconds with 10,000 iterations. The result of Tabu search is presented in Figure 3. Regarding Figure 3, the total distance is 107 Kilometer and the processed time is 54.11 seconds with 10,000 iterations. From the point of total distance, the TS algorithm has better result than SA which is 11.2% shorter. But from the point of time process, the algorithm of SA is faster than TS, about 60.18%. The goal of this study is to find the shortest route and not the fastest time process, then, the TS algorithm is matched with this goal.

In other studies, one can evaluate this both algorithm for larger sample size, for example 50 or 100 or more than 100 destinations in order to support this findings or the findings may give a different result from this study.

	DCH	CG6	CPM	PRM	KTA	LMP	GMP	MTA	NSF	MDS	MOI	EMP	MKG	SDA	THC	GIF	ARK	MLW	AMB	LSA	PI1	PFS	MKK	SCY	PSN	ECS	SPN	MBC	AMC
DCH	0	10	3	5	7	4	6	3	3	9	14	7	16	6	5	6	15	8	8	7	9	8	9	6	6	6	10	13	20
CG6	10	0	11	8	12	8	13	11	11	14	20	9	22	15	14	15	24	17	17	17	18	17	18	15	15	16	20	22	27
CPM	3	11	0	7	4	6	4	1	1	7	12	6	14	5	4	4	15	9	7	7	11	8	8	6	6	7	10	12	18
PRM	5	8	7	0	10	1	10	7	7	13	18	10	20	10	10	10	17	10	11	11	11	12	13	9	9	10	14	17	25
KTA	7	12	4	10	0	10	1	4	4	3	9	5	11	4	5	5	17	11	8	8	13	8	9	9	9	8	11	11	15
LMP	4	8	6	1	10	0	10	7	6	12	18	10	20	10	9	10	17	10	11	11	11	12	13	9	9	10	14	16	24
GMP	6	13	4	10	1	10	0	4	4	3	9	5	11	4	5	5	16	10	8	8	13	7	8	8	8	8	10	10	15
MTA	3	11	1	7	4	7	4	0	1	3	9	5	11	4	4	4	16	10	8	8	13	7	8	8	8	8	10	10	15
NSF	3	11	1	7	4	6	4	1	0	7	12	6	14	5	4	4	15	9	7	7	11	8	8	6	6	7	10	12	18
MDS	9	14	7	13	3	12	3	3	7	0	7	5	9	6	7	7	19	13	10	10	16	10	10	11	11	11	12	11	14
MOI	14	20	12	18	9	18	9	9	12	7	0	12	2	9	10	10	18	15	11	12	18	11	10	14	14	13	12	9	8
EMP	7	9	6	10	5	10	5	5	6	5	12	0	14	8	9	9	20	14	12	12	16	12	13	12	11	12	15	15	19
MKG	16	22	14	20	11	20	11	11	14	9	2	8	0	11	12	11	19	16	12	13	19	12	11	15	15	14	13	9	6
SDA	6	15	5	10	4	10	4	4	5	6	9	9	11	0	2	1	13	7	4	4	10	4	5	6	5	5	7	8	15
THC	5	14	4	10	5	9	5	4	4	7	10	9	12	2	0	1	12	6	4	4	9	4	5	5	4	4	7	8	16
GIF	6	15	4	10	5	10	5	4	4	7	10	20	11	1	1	0	12	6	4	4	9	4	5	5	5	4	6	8	15
ARK	15	24	15	17	17	17	16	16	15	19	18	14	19	13	12	12	0	7	9	9	7	9	9	10	10	9	7	10	20
MLW	8	17	9	10	11	10	10	10	9	13	15	12	16	7	6	6	7	0	4	4	3	5	5	3	3	3	5	9	19
AMB	8	17	7	11	8	11	8	8	7	10	11	12	12	4	4	4	9	4	0	1	7	1	2	4	4	2	3	6	16
LSA	7	17	7	11	8	11	8	8	7	10	12	16	13	4	4	4	9	4	1	0	7	2	3	3	3	2	4	7	16
PI1	9	18	11	11	13	11	13	13	11	16	18	12	19	10	9	9	7	3	7	7	0	8	8	5	5	6	8	12	22
PFS	8	17	8	12	8	12	7	7	8	10	11	13	12	4	4	4	9	5	1	2	8	0	1	5	4	3	3	5	15
MKK	9	18	8	13	9	13	8	8	8	10	10	12	11	5	5	5	9	5	2	3	8	1	0	5	5	4	2	5	14
SCY	6	15	6	9	9	9	8	8	6	11	14	11	15	6	5	5	10	3	4	3	5	5	5	0	1	2	6	9	19
PSN	6	15	6	9	9	9	8	8	6	11	14	12	15	5	4	5	10	3	4	3	5	4	5	1	0	2	6	9	18
ECS	6	16	7	10	8	10	8	8	7	11	13	15	14	5	4	4	9	3	2	2	6	3	4	2	2	0	5	8	17
SPN	10	20	10	14	11	14	10	10	10	12	12	15	13	7	7	6	7	5	3	4	8	3	2	6	6	5	0	5	15
MBC	13	22	12	17	11	16	10	10	12	11	9	19	9	8	8	8	10	9	6	7	12	5	5	9	9	8	5	0	11
AMC	20	27	18	25	15	24	15	15	18	14	8	19	6	15	16	15	20	19	16	16	22	15	14	19	18	17	15	11	0

Figure 2.
Distance data for 29 destinations

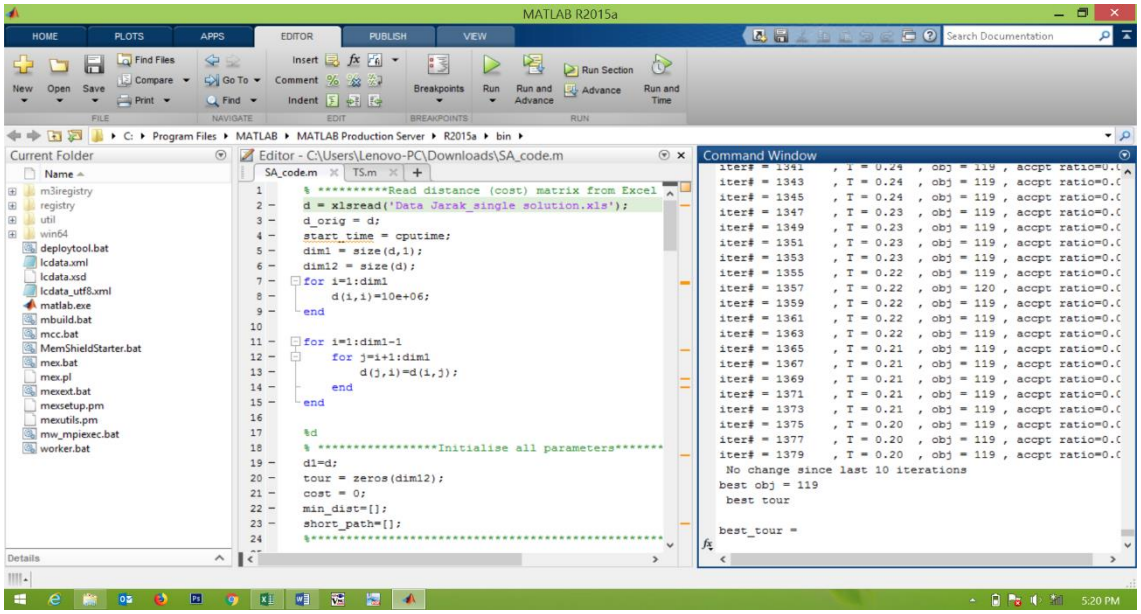

Figure 3.
The results of Simulated Annealing-SA

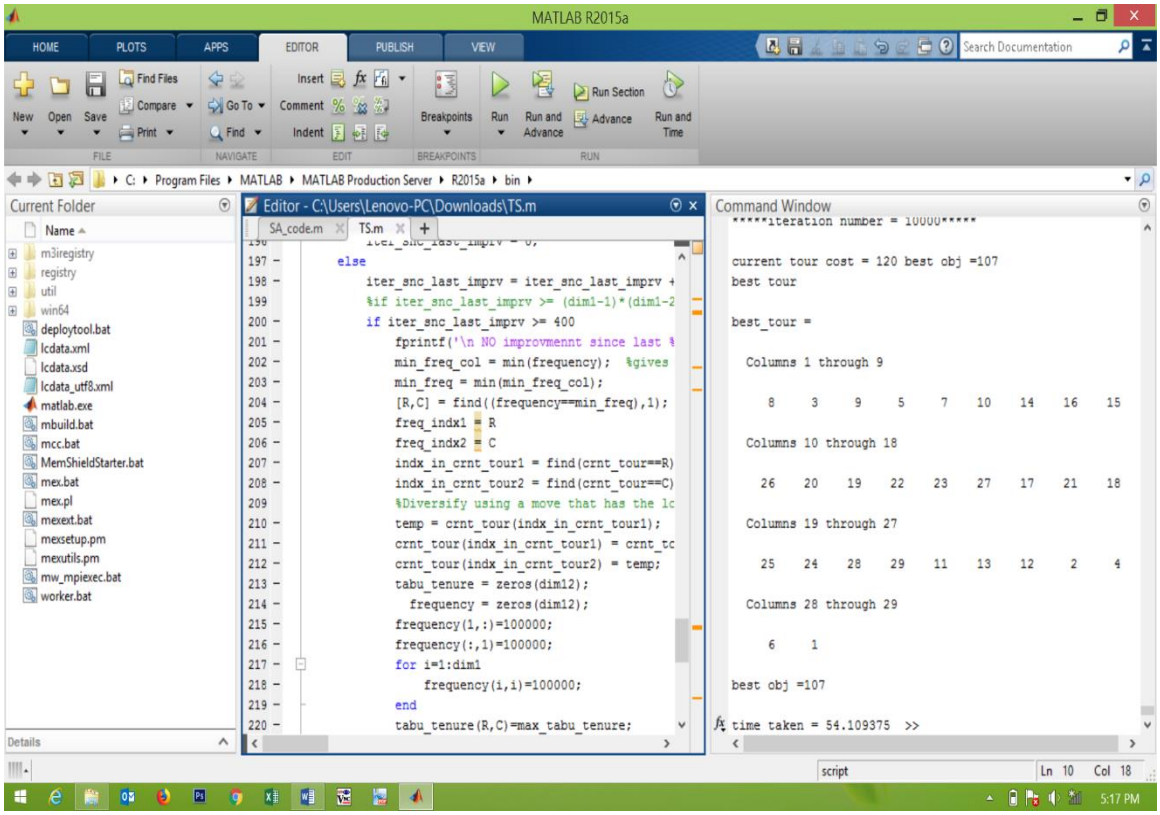

Figure 4.
The results of Tabu Search - TS

The results from both algorithms are summarized at Table 1. These results will be used to execute operational delivery daily from distribution center to 29 outlets and not in a random selection method.

Table 1.
Summary of Results from SA & TS

Algorithm	Distance (KM)	Time process (s)	Iteration
SA	119	33.78	10,000
TS	107	54.11	10.000

4. DISCUSSION

There are numerous optimization methods: exact and approximate methods for solving the traveling salesman problem. TS and SA are only two of well known methods. Researchers needs to compare these with exact algorithm in order to know the gap between exact and approximate methods. The gap includes distance and processing time.

5. CONCLUSION

In this research, the two methods of exploitation S-metaheuristics are compared to find the shortest route in deliverying to 29 destinations it is founded that Tabu Search. TS algorithm shows a better result which has 119 Kilometer distance and about 11.2% shorter than Simulated Annealing – SA algorithm. The next research need to be tested in larger destination size and compared with exploration metaheuristics in order to validate this result.

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