Mathematical Sciences and Informatics Journal
Vol. 5, No. 1, May 2024, pp. 1-9
http://www.mijuitm.com.my
DOI : 10.24191/mij.v5i1.916

An Integer Linear Programming Approach to the Travelling Salesman Problem for Optimizing Self-Drive Tourist Routes in Kuala Lumpur

Nur Azirah Suliman
College of Computing, Informatics and Mathematics, Universiti Teknologi MARA, Cawangan Negeri Sembilan, Kampus Seremban, Malaysia
2020963797@student.uitm.edu.my

Noorezatty Mohd Yusop
College of Computing, Informatics and Mathematics, Universiti Teknologi MARA, Cawangan Negeri Sembilan, Kampus Seremban, Malaysia
noorezatty@uitm.edu.my

Nurfaqihah Athirah Mat Janggi
College of Computing, Informatics and Mathematics, Universiti Teknologi MARA, Cawangan Negeri Sembilan, Kampus Seremban, Malaysia
2020978793@student.uitm.edu.my

Nur Shamira Shamimi Kamaruddin
College of Computing, Informatics and Mathematics, Universiti Teknologi MARA, Cawangan Negeri Sembilan, Kampus Seremban, Malaysia
2020994847@student.uitm.edu.my

Nora Mohd Basir
College of Computing, Informatics and Mathematics, Universiti Teknologi MARA, Cawangan Negeri Sembilan, Kampus Seremban, Malaysia
noram661@uitm.edu.my

Article Info

Article history:

Received Jan 05, 2024
Revised Feb 15, 2024
Accepted Apr 08, 2024

Keywords:

Integer Linear Programming
Routing problem
Optimization
Travelling Salesman Problem
Itinerary planning

ABSTRACT

Self-drive tourism offers tourists the flexibility to explore destinations at their own pace, utilizing private transport. However, it is essential to underscore the significance of thorough planning for a successful and enjoyable experience. The objective of this research is to explore the concept of travelling salesman problem and its application in optimizing travel routes for self-drive tourists visiting Kuala Lumpur. The study employed an Integer Linear Programming (ILP) model to propose efficient routes that connect all seven notable points of interest in Kuala Lumpur, including the Petronas Twin Towers, Batu Caves, Central Market, Merdeka Square, Bukit Bintang, KL Tower, and Titiwangsa Lake Garden. Implementation of ILP for suggested routes results in a reduction of approximately 36.86% in transportation distance, ultimately leading to a decrease in transportation costs. This demonstrates the effectiveness and efficiency of the proposed approach, enabling tourists to maximize their experience while minimizing time and energy spent navigating congested or inefficient roads. This research emphasizes the importance of self-drive tourism and the application of an ILP model in optimizing travel routes for tourists in Kuala Lumpur. By following the suggested routes, visitors can efficiently navigate the city's diverse neighborhoods and transportation options, while enjoying its notable attractions. The significant reduction in transportation distance achieved through this approach highlights its effectiveness in enhancing the travel experience in Kuala Lumpur.

Corresponding Author:
Noorezatty Mohd Yusop
Universiti Teknologi MARA Cawangan Negeri Sembilan Kampus Seremban
email: noorezatty@uitm.edu.my

PENERBIT PRESS
UNIVERSITI TEKNOLOGI MARA

1. Introduction

The tourism industry plays a vital role in the development and progress of nations, serving as a platform for promoting a country's culture and identity. Additionally, tourism activities generate economic benefits, create employment opportunities, and improve the nation’s infrastructure. In Malaysia, this sector holds significant importance in driving economic growth. According to the Department of Statistics Malaysia (DOSM), Malaysia's tourism industry contributed 12.8% (RM197.9 billion) to the gross domestic product (GDP) in 2021, a slight decrease from 14.1% in 2020. As reported by Tourism Malaysia, the nation has set ambitious targets for 2024, aiming to attract 27.3 million international tourists focusing on popular destinations such as Kuala Lumpur, Malacca, Penang, and Langkawi. While it's predicted that international travel will rise in 2024, local industry experts are of the opinion that domestic tourism will remain strong.

Kuala Lumpur, the dynamic capital city of Malaysia, embodies a fusion of diverse cultures, iconic landmarks, and captivating attractions. Kuala Lumpur entices visitors with its array of attractions, including modern architectural wonders, artistic displays, verdant parks, bustling food markets, historical landmarks, and a vibrant blend of ethnic cultures. Among these attractions, Kuala Lumpur City Centre (KLCC) stands out as a renowned commercial and entertainment hub in Malaysia. Also, Petronas Twin Towers, Aquaria KLCC, Jamek Mosque, Central Market, Petaling Street, Bintang Walk, and Batu Caves are prominent tourist destinations in Kuala Lumpur [1]. These iconic landmarks have captivated millions of tourists from around the globe.

In domestic tourism, self-drive tourism has gained significant popularity, providing tourists with a flexible and personalised way to explore their destination of choice. By taking control of their transportation, tourists can tailor their journeys to their specific interests and preferences, allowing for a more personalized and immersive experience. The use of digital information and communication technology (ICT) has become a significant factor in influencing the decision-making of self-drive tourists. Wireless technologies, location-based systems, geographical information systems, intelligent transport systems, virtual tourism, and virtual communities help in planning and decision among travellers [2]. While resources for general vacation planning are available, there is a noticeable gap in research specifically focusing on route optimization. Thorough route planning is essential for enhancing the overall travel experience. By devising efficient routes, tourists are empowered to maximise their time, fully immerse themselves in the city's diverse attractions, and forge enduring memories of their journey.

Routing problem known as Travelling Salesman Problem (TSP) is a topic of interest in combinatorial optimisation since 1930 [3]. TSP is a well-known problem that seeks to identify the most economical route among a set of locations, with the constraint of visiting each place only once and returning to the starting location [3], [4]. In order to enhance the tourist experience when visiting various destinations, it is necessary to develop a shortest route model. Existing studies conducted in Malaysia effectively optimized travel routes in popular destinations such as Langkawi and Terengganu [5], [6]. However, a limitation exists concerning self-drive tourists in Kuala Lumpur, encompassing aspects such as route selection and specific user preferences. This paper specifically examines the travelling salesman problem using integer programming in the context of self-drive tourism in Kuala Lumpur city. The aim of the study is to maximise tourist visits to seven locations by minimising travel distances. The study provides useful insights, leading to a more comprehensive understanding of the practicalities and complexities of route optimisation for self-driving tourism in Kuala Lumpur.

2. Literature Review

The Travelling Salesman Problem (TSP) is a well-known algorithmic problem that involves finding the shortest route between a set of points and locations to be visited. It is extensively utilised in operations research to minimise cost. A prevalent use of the TSP is optimising the movement of people, equipment, and vehicles during tours to minimise the overall cost of travel. The definition of cost can differ depending on the specific problem at hand. It can be measured in terms of distance, time, price, or any other variable that is to be optimised [7].

Despite its deceptively simple appearance, TSP remains one of the most challenging problems in the field of Operational Research [7]. TSP offers several advantages and is frequently employed to determine the most efficient path across various nodes or locations. It focuses on identifying the fastest, easiest, and most effective route. Routing optimization is a critical aspect of various fields, including transportation [8-10], supply chain [11-14] and telecommunications [15]. In recent years, researchers have increasingly turned to integer programming as a powerful tool to address the complex nature of routing problems. Within the tourism industry, the optimisation approach was applied by [7], [16-23] to solve routing problem.

One of the studies utilized the integer programming model to assist in identifying a route that encompasses the most appealing tourist spots in Langkawi while minimising the traveller's time and overall trip expenses. The researchers concluded that the suggested TSP model proved beneficial in guiding tourists in selecting an appropriate path when visiting attractive areas. It was observed that TSP aided tourists in devising travel plans that effectively reduced travel costs [5].

Another study conducted by [24] aimed to formulate the cycle-tourist route-planning problem with multiple objectives. The goal was to maximise the utility of cycle tourists visiting POIs, minimise total travel time, maximise the Bicycle Level of Service (BLOS), and reduce the number of intersections on the cycle route. The study also considered factors such as monetary and time budgets. To optimise the cycle-tourist route plan, a multi-objective mixed integer linear programming model was developed. The proposed model holds the potential to assist local governments and agencies in promoting cycle-tourism, as well as aiding cycle-tourists in planning routes that align with their personal preferences, within the framework of a sustainable transportation system.

In the case of Kuala Lumpur, a similar methodology was applied in a study conducted by [1]. They developed a mathematical model with specific constraints to minimise the total tour distance while visiting five destinations in the city. The model successfully addressed the routing problem of the Go KL City Bus, considering 120 routes. In conclusion, solving the TSP and employing similar optimisation models assist in determining optimised routes that minimise travel distance, ensuring efficient coverage of desired POIs in Kuala Lumpur. Such methodologies contribute to efficient travel planning, cost reduction, and a satisfying tourist experience.

3. Methodology

3.1 The Source of Data

The objective of this study is to determine an optimal sequence for seven Points of Interest (POIs) tailored for self-drive tourists, with the goal of reducing the total distance covered. These POIs are detailed in Table 1. All POIs are located within Kuala Lumpur, Malaysia.

Table 1. Kuala Lumpur Points of Interest

POIs	Description
Petronas Twin Towers	Standing as an iconic symbol of Kuala Lumpur, the Twin Towers are among the world's tallest skyscrapers and offer breathtaking panoramic views from their observation deck.
Batu Caves	A sacred Hindu shrine located on the outskirts of the city. Batu Caves features a massive limestone hill with a series of caves housing ornate temples and vibrant religious festivities.
Central Market	It is housed in a beautiful heritage building. Central Market is a cultural hub where visitors can explore local arts and crafts and traditional Malaysian products and experience live performances.
Merdeka Square	Also known as Dataran Merdeka, this historic square marks the spot where Malaysia's independence was declared. It is surrounded by impressive colonial-era buildings and has hosted numerous national celebrations.
Bukit Bintang	Known as the city's entertainment and shopping district, Bukit Bintang is a bustling area lined with shopping malls, upscale boutiques, street food stalls, and vibrant nightlife venues. It is a popular destination for shopping enthusiasts and food lovers.
Kuala Lumpur Tower	Also known as KL Tower, it is an iconic telecommunications and observation tower located in the heart of Kuala Lumpur, Malaysia. It is one of the prominent landmarks in the city and a popular tourist attraction.
Titiwangsa Lake Garden	Titiwangsa Lake Garden in Kuala Lumpur is a beautiful park where visitors can enjoy various outdoor activities amidst lush greenery and serene lake views.

The distances between two destinations were calculated by considering their respective latitude and longitude coordinates and road network using online maps distance estimator. The resulting distances were then utilised to establish the relationships between POIs under investigation. The abbreviation of the POIs used in this study and their corresponding estimated distances are presented in Table 2 and Table 3, respectively.

Table 2. Points of interest of the study

POIs	**Abbreviation**
Petronas Twin Towers	TT
Batu Caves	BC
Central Market	CM
Merdeka Square	MS
Bukit Bintang	BB
Kuala Lumpur Tower	KT
Titiwangsa Lake Garden	LG

Table 3. Travel distance (km) for POIs in Kuala Lumpur

POIs	**TT**	**CM**	**LG**	**MS**	**BB**	**KT**	**BC**
TT	0	3.5	6.7	3.8	1.9	2.3	13.1
CM	3.5	0	7.3	0.7	2.4	2.7	15.4
LG	6.7	7.3	0	6.3	6.2	6.8	10.3
MS	3.8	0.70	6.3	0	3.4	2.8	13.2
BB	1.9	2.4	6.2	3.4	0	1.9	16.6
KT	2.3	2.7	6.8	2.8	1.9	0	15
BC	13.1	15.4	10.3	13.2	16.6	15	0

The distances between POIs in Kuala Lumpur vary, impacting self-drive tourism experiences. The longest distance is approximately 16.6 kilometres from Bukit Bintang to Batu Caves, while the shortest distance is around 0.7 kilometres from Merdeka Square to Central Market. Understanding these longest and shortest distances aids in optimising travel itineraries for self-drive tourists exploring Kuala Lumpur.

3.2 Integer Programming Model

This study utlised a 0-1 integer programming model to address the problem of TSP, as outlined in reference [25]. This mathematical approach as given in the series of equations below was applied to systematically determine the most efficient route for connecting the identified POIs in Kuala Lumpur, thereby minimizing travel distance while maximizing the tourism experience.

$$\text{Minimize } D = \sum_i \sum_j d_{ij} X_{ij} \tag{1}$$

subject to:

$$\sum_{i=1}^{i=7} X_{ij} = 1 \qquad (j = 1, 2, ..., 7) \tag{2}$$

$$\sum_{j=1}^{j=7} X_{ij} = 1 \qquad (i = 1, 2, ..., 7) \tag{3}$$

$$u_i - u_j + 7X_{ij} \le 6 \quad (i \ne j; i = 2, 3, ..., 7; j = 2, 3, ..., 7)$$
$$X_{ij} \in \{0,1\}, u_{ij} \ge 0 \tag{4}$$

where:

D = total distance
i = index for origin tourist destination
j = index for next tourist destination
X_{ij} = path from destination i to destination j
d_{ij} = distance (km) from tourist destination i to tourist destination j
u_i = the sequence number of tourist destination i on the tour
u_j = the sequence number of tourist destination j on the tour

The mathematical model involves minimizing the total distance D traveled, represented by equation (1), subject to a series of linear constraints. Variable X_{ij} denotes the decision to travel from POI i to POI j, which takes a value of 1 if the path is chosen and 0 otherwise. The distance between any two points i and j denoted by d_{ij}.

Constraints (2) and (3) ensure that each POI is entered and exited exactly once, promoting the continuity of the tour. Constraint (4) is designed to prevent sub-tours, ensuring a single, cohesive tour through all POIs by enforcing an order of sequence between the points visited, represented by variables u_i and u_j, which denote the sequence number of tourist destination i and j on the tour. This approach, which employed 0-1 integer programming, translates the TSP into a solvable optimization problem.

4. Results and Discussion

The TSP was solved using Excel solver to determine the optimal route and minimum distance. The results obtained from the analysis, as presented in Table 4, displayed the sequence of routes for the optimal solution. The route started from Batu Caves (BC), proceeded to Petronas Twin Tower (TT), Bukit Bintang (BB), KL Tower (KT), Central Market (CM), Merdeka Square (MS), finally Titiwangsa Lake Garden (LG). The minimum distance required to visit all the POIs was found to be 36.90km.

Table 4. Optimal Tour Routes

Sequence	From	To	Distance (km)
1	Batu Caves	Petronas Twin Tower	13.10
2	Petronas Twin Tower	Bukit Bintang	1.90
3	Bukit Bintang	KL Tower	1.90
4	KL Tower	Central Market	2.70
5	Central Market	Merdeka Square	0.70
6	Merdeka Square	Titiwangsa Lake Gardens	6.30
7	Titiwangsa Lake Gardens	Batu Caves	10.30
		Total Distance	**36.90**

Among the identified routes in Table 4, the longest distance was from Batu Caves (BC) to Petronas Twin Tower (TT), spanning 13.10km, while the shortest distance was from Central Market (CM) to Merdeka Square (MS), covering a mere 0.70km. The findings of this analysis successfully achieved the objective of developing a mathematical model for tour routes that minimise travel distance. It is critical to note that starting the journey from any point in the sequence would yield a similar total distance. In this case, although there were seven different starting nodes resulting in different paths, the total distance remained as 36.90km since tourists would visit all destinations.

Conversely, if a tourist were to follow a random path, as in Table 5, without employing the optimisation approach, the total distance increases to 50.50 km. This represents a 36.86% increase in the total distance compared to utilising the optimisation approach. Thus, this study provides compelling evidence that the use of integer programming is beneficial for tourists in minimising travel distances and eventually minimizing transportation cost.

Table 5. Random Tour Routes

Sequence	From	To	Distance (km)
1	Petronas Twin Tower	Central Market	3.50
2	Central Market	Titiwangsa Lake Gardens	7.30
3	Titiwangsa Lake Gardens	Merdeka Square	6.30
4	Merdeka Square	Bukit Bintang	3.40
5	Bukit Bintang	KL Tower	1.90
6	KL Tower	Batu Caves	15.00
7	Batu Caves	Petronas Twin Tower	13.10
		Total Distance	**50.50**

The satisfaction of tourists with the cities they visited is influenced by the routes they choose [26]. The implementation of optimisation approaches in this work has emerged as a pivotal factor in the successful reduction of routing distances. Studies conducted by [5], [6], [18], and [23] supports the finding that the implementation of optimisation techniques leads to a significant reduction in both the overall cost and distance. Similar outcomes have been observed in diverse fields, including transportation systems, and supply chain logistics.

5. Conclusion

In conclusion, the research findings demonstrate the effectiveness of employing integer linear programming as a valuable approach for optimising travel routes and minimising transportation costs in Kuala Lumpur. The analysis revealed an optimal route spanning 36.90km, ensuring efficient coverage of all the POIs in the city. This optimisation approach significantly outperformed the regular path option, which resulted in a 36.86% increase in total distance.

The results highlight the importance of leveraging mathematical modelling techniques and optimisation methods to enhance the tourist experience. By employing integer linear programming, tourists can make the most of their time, explore diverse attractions, and create lasting memories during their visit to Kuala Lumpur. This approach ensures a seamless and enjoyable travel experience by minimising transportation costs and facilitating efficient exploration of the city.

The findings of this research provide valuable insights for stakeholders in the tourism industry, including tour operators, travel agencies, and local government bodies. By incorporating the developed mathematical model into travel planning and itinerary recommendations, these stakeholders can enhance the overall satisfaction of tourists while promoting sustainable tourism practices.

Future research directions could involve expanding the scope of the study to include additional cities or regions, integrating real-time data for dynamic route planning, and incorporating other factors such as traffic conditions and tourist preferences. By continuously refining and applying optimisation techniques, the tourism industry can continue to improve travel experiences and promote efficient exploration of diverse destinations.

Acknowledgements

The authors would like to thank Universiti Teknologi MARA Negeri Sembilan, Seremban Branch Campus for the facilities involved in making this research a success.

Conflict of Interest

The authors declare no conflict of interest in the subject matter or materials discussed in this manuscript.

References

[1] W. N. A. W. A. Fatthi, M. H. M. Haris, and H. Kahtan, "Application of travelling salesman problem for minimizing travel distance of a two-day trip in Kuala Lumpur via go KL city bus," in *Intelligent Computing & Optimization*, Cham: Springer International Publishing, 2019, pp. 277-284, doi: 10.1007/978-3-030-00979-3_28.

[2] L. Hattingh, "Going out-there: a literature review on drive tourism within the South African context," *African Journal of Hospitality, Tourism and Leisure*, vol. 11, no. Special Edition, pp. 595-616, 2022, doi: 10.46222/ajhtl.19770720.245.

[3] P. C. Pop, O. Cosma, C. Sabo, and C. P. Sitar, "A comprehensive survey on the generalized traveling salesman problem," *European Journal of Operational Research*, vol. 314, no. 3. 2024, doi: 10.1016/j.ejor.2023.07.022.

[4] M. Mosayebi, M. Sodhi, and T. A. Wettergren, "The traveling salesman problem with job-times (TSPJ)," *Computers & Operations Research*, vol. 129, 2021, p. 105226, doi: 10.1016/j.cor.2021.105226.

[5] Z. Hashim and W. R. Ismail, "Applications of travelling salesman problem in optimizing tourist destinations visit in Langkawi," in *Regional Conference on Science, Technology and Social Sciences (RCSTSS 2014)*, 2016, pp. 265-273, doi: 10.1007/978-981-10-0534-3_25.

[6] Z. Hashim and W. R. Ismail, "Self-drive tourism route in Terengganu: An application of goal programming model," *Sains Humanika*, vol. 9, no. 1-5, 2017, doi: 10.11113/sh.v9n1-5.1176.

[7] Z. Hashim, W. L. H. Mat Desa, H. A. Aziz, and N. M. Z. Mohd Zaki, "Greedy method for solving the Langkawi tourist route: A case study," *Journal of Technology and Operations Management*, vol. 13, no. 1. 2018, pp. 21-29, doi: 10.32890/jtom2018.13.1.3.

[8] R. Guo, W. Guan, and W. Zhang, "Route design problem of customized buses: Mixed integer programming model and case study," *Journal of Transportation Engineering, Part A: Systems*, vol. 144, no. 11, 2018, p. 04018069, doi: 10.1061/jtepbs.0000185.

[9] A. K. Jha, G. S. Sharma, and N. Kaushik, "Modeling of transport problem in linear programming with python (PULP)," *SAMRIDDHI: A Journal of Physical Sciences, Engineering and Technology*, vol. 15, no. 01, 2023, pp. 104-108, doi: 10.18090/samriddhi.v15i01.14.

[10] P. T. Giavarina dos Santos, E. Kretschmann, D. Borenstein, and P. C. Guedes, "Cargo routing and scheduling problem in deep-sea transportation: Case study from a fertilizer company," *Computers & Operations Research*, vol. 119, 2020, p. 104934, doi: 10.1016/j.cor.2020.104934.

[11] A. De, M. Gorton, C. Hubbard, and P. Aditjandra, "Optimization model for sustainable food supply chains: An application to Norwegian salmon," *Transportation Research Part E: Logistics and Transportation Review*, vol. 161, 2022, p. 102723, doi: 10.1016/j.tre.2022.102723.

[12] N. Nurdin, T. Taufiq, B. Bustami, M. Marleni, and K. Khairuni, "Optimization model of fishery products supply chain using mixed integer linear programming method," *Journal of Informatics and Telecommunication Engineering*, vol. 6, no. 2, 2023, pp. 378-392, doi: 10.31289/jite.v6i2.8186.

[13] W. Cao and X. Wang, "A multiobjective multiperiod mixed-integer programming optimization model for integrated scheduling of supply chain under demand uncertainty," *IEEE Access*, vol. 10, 2022, pp. 63958-63970, doi: 10.1109/ACCESS.2022.3183281.

[14] A. Pedram, S. Sorooshian, F. Mulubrhan, and A. Abbaspour, "Incorporating vehicle-routing problems into a closed-loop supply chain network using a mixed-integer linear-programming model," *Sustainability (Switzerland)*, vol. 15, no. 4, 2023, p. 2967, doi: 10.3390/su15042967.

[15] A. Naeem, S. S. Qurashi, Y. Khan, S. Ahmed, and N. Safwan, "Fiber to the home (FTTH) automation planning, its impact on customer satisfaction & cost-effectiveness," *Wireless Personal Communications*, vol. 117, no. 2, 2021, pp. 503-524, doi: 10.1007/s11277-020-07880-4.

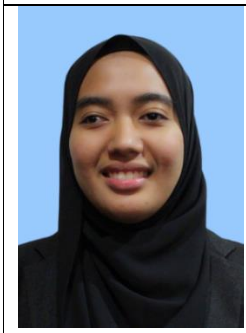
[16] P. Thumrongvut, K. Sethanan, R. Pitakaso, T. Jamrus, and P. Golinska-Dawson, "Application of industry 3.5 approach for planning of more sustainable supply chain operations for tourism service providers," *International Journal of Logistics Research and Applications*, vol. 26, no. 11, 2023, pp. 1578-1601, doi: 10.1080/13675567.2022.2090529.

[17] V. K. Fedorchenko, O. V. Parubets, L. Y. Krasavtceva, L. V. Hrybova, and O. A. Kruchek, "Mechanisms for the integration of tourism systems: Types, problems, prospects," *Geo Journal of Tourism and Geosites*, vol. 32, no. 4, 2020, pp. 1229-1237, doi: 10.30892/gtg.32406-562.

[18] A. Supithak, W. Supithak, and P. Tosak, "Vehicle scheduling for tourism routing problem," in *6th International Conference on Business and Industrial Research, ICBIR 2021 - Proceedings*, 2021, pp. 142-146, doi: 10.1109/ICBIR52339.2021.9465844.
[19] S. Li, T. Luo, L. Wang, L. Xing, and T. Ren, "Tourism route optimization based on improved knowledge ant colony algorithm," *Complex and Intelligent Systems*, 2022, pp. 3973-3988, doi: 10.1007/s40747-021-00635-z.
[20] Y. Zhang, L. Jiao, Z. Yu, Z. Lin, and M. Gan, "A tourism route-planning approach based on comprehensive attractiveness," *IEEE Access*, vol. 8, 2020, pp. 39536-39547, doi: 10.1109/ACCESS.2020.2967060.
[21] C. E. Silva *et al.*, "Route scheduling system for multiple self-driving cars using k-means and bio-inspired algorithms," in *International Conference on Engineering Applications of Neural Networks*, 2022, pp. 27-39, doi: 10.1007/978-3-031-08223-8_3.
[22] R. Carr, R. Ravi, and N. Simonetti, "A new integer programming formulation of the graphical traveling salesman problem," *Math Program*, vol. 197, no. 2, 2023, pp. 877-902, doi: 10.1007/s10107-022-01849-w.
[23] O. Nurdiawan, F. A. Pratama, D. A. Kurnia, Kaslani, and N. Rahaningsih, "Optimization of traveling salesman problem on scheduling tour packages using genetic algorithms," in *Journal of Physics: Conference Series*, 2020, p. 052037, doi: 10.1088/1742-6596/1477/5/052037.
[24] S. Zhu, "Multi-objective route planning problem for cycle-tourists," *Transportation Letters*, vol. 14, no. 3, 2022, pp. 298-306, doi: 10.1080/19427867.2020.1860355.
[25] W. L. Winston, *Operations Research Applications and Algorithms 4th Edition*, 2004.
[26] J. C. Martin, C. Román, P. Moreira, R. Moreno, and F. Oyarce, "Does the access transport mode affect visitors' satisfaction in a World Heritage City? The case of Valparaiso, Chile," *Journal of Transport Geography*, vol. 91, 2021, p. 102969, doi: 10.1016/j.jtrangeo.2021.102969.

Biography of all authors

Picture	Biography	Authorship contribution
	Nur Azirah Suliman has completed her degree program in statistics from College of Computing, Informatics and Mathematics, Universiti Teknologi MARA, Cawangan Negeri Sembilan, Kampus Seremban. Her exposure to research during her studies has allowed her to develop a deep understanding of statistical methodologies and their practical applications and currently develops research interest in applied statistics and operations research.	Design the research work, data collection, data analysis and interpretation. Author has reviewed and approved the final manuscript.
	Noorezatty Mohd Yusop is a senior lecturer at College of Computing, Informatics and Mathematics, Universiti Teknologi MARA, Cawangan Negeri Sembilan, Kampus Seremban. She is also a member of the special interest group in Data Science and Predictive Analytics (DASCA), UiTM Negeri Sembilan. Her research interests include operational research, applied statistics and text mining.	Design the research work, analysis, interpretation, and drafting article. Author has reviewed and approved the final manuscript.

	Nurfaqihah Athirah Mat Janggi has completed her degree program in statistics from College of Computing, Informatics and Mathematics, Universiti Teknologi MARA, Cawangan Negeri Sembilan, Kampus Seremban. Her exposure to research during her studies has allowed her to develop a deep understanding of statistical methodologies and their practical applications and currently develops research interest in applied statistics and operations research.	Design the research work, data collection, data analysis and interpretation. Author has reviewed and approved the final manuscript.
	Nur Shamira Shamimi Kamaruddin has completed her degree program in statistics from College of Computing, Informatics and Mathematics, Universiti Teknologi MARA, Cawangan Negeri Sembilan, Kampus Seremban. Her exposure to research during her studies has allowed her to develop a deep understanding of statistical methodologies and their practical applications and currently develops research interest in applied statistics and operations research.	Design the research work, data collection, data analysis and interpretation. Author has reviewed and approved the final manuscript.
	Nora Mohd Basir is a senior lecturer at College of Computing, Informatics and Mathematics, Universiti Teknologi MARA, Cawangan Negeri Sembilan, Kampus Seremban. Currently, she is pursuing PHD in applied statistics. Her current research interests include applied statistics, higher education studies and social sciences studies.	Interpretation and drafting article. Author has reviewed and approved the final manuscript.