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Travelling Saleman Problem via Ant Colony Optimization – An Application Toward Kedah Tourism

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Abstract

Optimization of tourism is important for both the travel experience and operational effectiveness, especially in a state with a lot of attractions such as Kedah, Malaysia. However, planning an efficient travel route that visits multiple dispersed attractions while minimizing total travel distance remains a significant logistical challenge, a problem classically formulated as the Travelling Salesman Problem (TSP). This study demonstrates the application of Ant Colony Optimization (ACO) algorithm to solve the TSP for tourism in Kedah. The aim of this study was to identify the most efficient and shortest travel route for tourists to have the best experiences in visiting the top interesting places in Kedah. The ACO algorithm was used, resulting in a reduced total travel distance of 239.4 kilometres. This optimized route not only minimizes travel time and costs but also ensures a clear journey for tourists. The accurate solution is produced by comparing the ACO algorithm results with manual calculations which highlighting the algorithm. Overall, this study offers valuable insights for tourism logistics which provide a useful tool for minimizing travel routes, reducing operational costs, and creating memorable trips for tourists in Kedah.

1. Introduction

Tourism optimization plays an important role in improving both operational efficiency and the travel experience, for example, in regions with many tourist attractions. Kedah, one of the states in Malaysia, offering a large scale in variety of cultural, natural, and relaxing locations. One of the major challenges in tourism management is optimizing travel routes to save time, reduce costs, and improve the efficiency of transportation systems. The Travelling Salesman Problem (TSP), a well-known optimization problem, is used to determine the most efficient route that visits each location exactly once and returns to the starting point [1] [2]. Indeed, solving this problem especially in sectors like tourism is very helpful and practical, where route planning directly affects both operational costs and customer satisfaction.

In Kedah, optimizing tourism routes can lead to important progress in travel efficiency and tourist satisfaction. This study uses Ant Colony Optimization (ACO) algorithm to solve the TSP for several tourist destinations in the state, such as Alor Setar Tower, Mount Jerai, Paddy Museum and others. The aim of the research is to identify the best route that minimizes travel time and distance, in the end improving tourism management and route planning. By using present optimization techniques like ACO algorithm into tourism planning, this study demonstrates how data-driven approaches can reduce the logistics of travel, minimize transportation costs, and improve the overall efficiency of tourism planning in Kedah [3].

Due to its biological inspiration, which is based on the behaviour of ants, the ACO algorithm has created a lot of attraction for solving TSP [2]. ACO algorithm mimics the way ants release pheromones along their paths. By stronger or thicker pheromone trails, the ants were more interested in the path. These will turn to improve the route's exploration [4]. This process allows the algorithm to converge on optimal or near-optimal solutions. It is making it highly effective for solving complex routing problems like TSP. In tourism, ACO algorithm has been successfully used for route optimization, providing a practical method for reducing travel distance and time, therefore improving the tourist experience and reducing functional costs for travel companies.

This paper explores the application of ACO for tourism route optimization specially focusing on the best places in Kedah. The aim is to save travel time and minimize distance for tourists visiting a few locations. The result from this study is expected to make an important decision for the tourism industry by offering a tool to improve travel planning and leave the best experiences for all of tourist. The following sections will discuss the methodology, results, and implications of applying ACO algorithm to tourism route optimization in Kedah, providing practical solutions to real-world challenges in the tourism sector.

2. Methodology

Collecting data on the tourist locations in Kedah is the first step in the methodology. The locations selected for this study include Alor Setar Tower, Paddy Museum, Mount Jerai, Seri Perigi Waterfall, Ulu Legong Hot Springs, Mount Keriang, Fantasia Aquapark, and Merdeka Beach. The distances between them are sourced from publicly available data which is Google Maps for each of these locations.

Next, the Ant Colony Optimization (ACO) algorithm is used to minimize the distances between all locations. To determine the most effective path between many locations, the ACO algorithm is a method that was motivated by the foraging behaviour of ants and is used in this study. This method works by simulating how ants move to find food sources and leave pheromone trails, which leave a pheromone that can make other ants smell it. The ants will use the path that has many pheromones. In the context of route planning, ACO algorithm consistently improves the result based on these pheromone trails, making the optimized distances dynamic and adaptable to real-world travel problems, especially in situations related to tourism.

2.1 Implementation of the ACO algorithm

The Ant Colony Optimization (ACO) algorithm is used to determine the optimal route between the tourist locations. ACO algorithm is a method of metaheuristic optimization that is inspired by the behavior of ants in the environment. In this method, artificial ants are used to explore potential routes. The algorithm starts with the following steps [5]:

Step 1: Start by putting up the algorithm parameters such as the number of ants (k), the number of cycles as in equation (1), the pheromone decay rate (ρ), the initial pheromone level (τ_0), and the importance of the heuristic function (β). Also, initialize the pheromone matrix (N x N), where each τ_{ij} represents the level.

Step 2: Place ants at their starting positions.

Step 3: Introduce a new variable (q), randomly sampled from a uniform distribution between 0 and 1. If $q \le q0$, choose the next destination using equation (2); otherwise, the next way decision is made using equation (3).

$$p_{ij} = \frac{(\tau_{ij})^{\alpha}.(n_{ij})^{\beta}}{\sum(\tau_{ij})^{\alpha}.(n_{ij})^{\beta}} \tag{1}$$

$$P_{k(i,j)} = \arg - \max\{(\tau_{iz}).(n_{iz})^{\beta}\} \tag{2}$$

$$P_{k(i,j)} = \left\{\frac{(\tau_{ij}).(n_{ij})^{\beta}}{\sum \quad _{z\in jk}(i)(\tau_{iz}).(n_{iz})^{\beta}}\right\} \tag{3}$$

Step 4: If the ant has not visited all the locations, repeat Step 3. Once all locations have been visited, the ant returns to the starting point, and the total distance the ant travels is calculated. The local pheromone level is then updated using equation (4).

$$\tau_{IJ} = (1 - \rho) * \tau_{IJ} + \rho * \tau_0, \tag{4}$$

Step 5: After all ants complete their tours in a cycle, the optimal route is decided, and the global pheromone level is updated using equation (5).

$$\tau_{IJ} = (1 - \rho) * \tau_{IJ} + \rho(1_{mc})^{-1} \tag{5}$$

Step 6: Repeat Steps 2-5 until the number of iterations reaches the final limit from Step 1.

3. Result and Discussion

The application of the Ant Colony Optimization (ACO) algorithm to solve the Travelling Salesman Problem (TSP) especially optimize travel routes in Kedah, which means reducing both travel time and distance, by effectively understanding and taking advantage of possible routes. The algorithm is identifying the shortest paths and helping tourists visiting a few locations in Kedah to plan their trips more effectively. This section presents the results obtained from the ACO algorithm, comparing them with manually calculated routes, and discusses the impact of these findings.

3.1 Related Data

Fig. 1 The maps of attraction place in Kedah

Fig. 1 shows that the map of attraction in Kedah, Malaysia which visually defines the logistical challenge at the heart of this study. It highlights a selection of the state's key tourist attractions including the Alor Setar Tower, Paddy Museum, Mount Jerai, Seri Perigi Waterfall, Ulu Legong Hot Springs, Mount Keriang, and Merdeka Beach distributed across diverse regions from the coastal northwest to the inland eastern districts. These sites, labelled as Selected on the map, are interconnected by a network of roads and highways illustrating the complex web of possible travel paths. The geographical dispersion of these attractions makes the task of planning an efficient, time-saving, and cost-effective tour itinerary a non-trivial problem.

This spatial layout directly presents a classic optimization challenge of how a tourist or tour operator can visit all these desired locations in a single trip while minimizing total travel distance. This is precisely the formulation of the Travelling Salesman Problem (TSP). To solve this practical problem for Kedah's tourism sector, this study uses the Ant Colony Optimization (ACO) algorithm. Inspired by the natural path-finding behaviour of ants, ACO is particularly suited for discovering the shortest possible route connecting all selected points on the map, thereby transforming the geographical complexity depicted into an optimized, actionable travel circuit. The following sections detail the methodology, application, and results of using ACO to derive the most efficient tourist route for Kedah.

Table 1 shows that the list of places in Kedah includes various notable locations. For each notable was identified by a letter for easy understanding. These places, such as Alor Setar Tower, Paddy Museum, Mount Jerai, and others, are important landmarks in Kedah. It shows a mix of cultural, natural, and relaxing attractions. This list can be used for tourism.

Table 1 The list of tourist attraction in Kedah

Node	Attraction Tourist Place in Kedah
a	Alor Setar Tower
b	Paddy Museum
c	Mount Jerai
d	Seri Perigi Waterfall
e	Ulu Legong Hot Spring
f	Mount Keriang

g	Fantasia Aquapark
h	Merdeka Beach

Table 2 Distance (km) between attractive places in Kedah

From/ To (km)	a	b	c	d	e	f	g	h
A	0	12.5	34.2	40.1	118	16.9	55.5	54.5
B	12.5	0	28.9	32.5	115	25.5	50.5	49.5
C	34.2	28.9	0	14.5	95.5	45	35.1	33.5
D	40.1	32.5	14.5	0	90.5	50	30.2	28.5
E	118.0	115	95.5	90.5	0	135	110	115
F	16.9	25.5	45	50	135	0	70.2	75
G	55.5	50.5	35.1	30.2	110	70.2	0	10.5
H	54.5	49.5	33.5	28.5	115	75	10.5	0

Table 2 presents the symmetric distance matrix in kilometres between the eight key tourist attractions in Kedah, forming the essential quantitative backbone for this route optimization study. Structured with rows and columns each labelled 'a' through 'h', corresponding to locations from Alor Setar Tower to Merdeka Beach. The table provides the precise road distance for every possible direct travel segment between these points. As a symmetric matrix, each off-diagonal entry, such as the 12.5 km between 'a' (Alor Setar Tower) and 'b' (Paddy Museum), is mirrored across the diagonal, accurately reflecting real-world, bidirectional travel. The distances reveal a geographically dispersed network, with the shortest link being a mere 10.5 km between Fantasia Aquapark (g) and Merdeka Beach (h), while the longest exceeds 135 km between Mount Keriang (f) and Ulu Legong Hot Springs (e). This substantial range highlights the critical need for optimization: an inefficient route could involve several such long hauls, drastically increasing travel time and cost. For the Ant Colony Optimization algorithm, this matrix is not just a dataset but the definitive landscape of the problem. Each value directly influences the artificial ants' "pheromone" calculations and path selection probabilities, guiding the iterative search toward the minimal total travel distance. Consequently, this table translates Kedah's physical geography into a solvable mathematical graph, enabling the derivation of a practical, efficient tourist circuit that minimizes redundancy and maximizes logistical efficiency.

3.2 Result from Ant Colony Optimization

Effective route planning is important in tourism for improving the travel experience, reducing travel time, and ensuring that visitors make the most of their trips. By optimizing routes between various tourist locations, travel agencies and tour planners can create more interesting itineraries. In this study, the focus is on Kedah, a state known for its natural beauty, cultural landmarks, and historical places. The goal is to determine the most efficient route for tourists to visit all of these attractive places while minimizing travel distance.

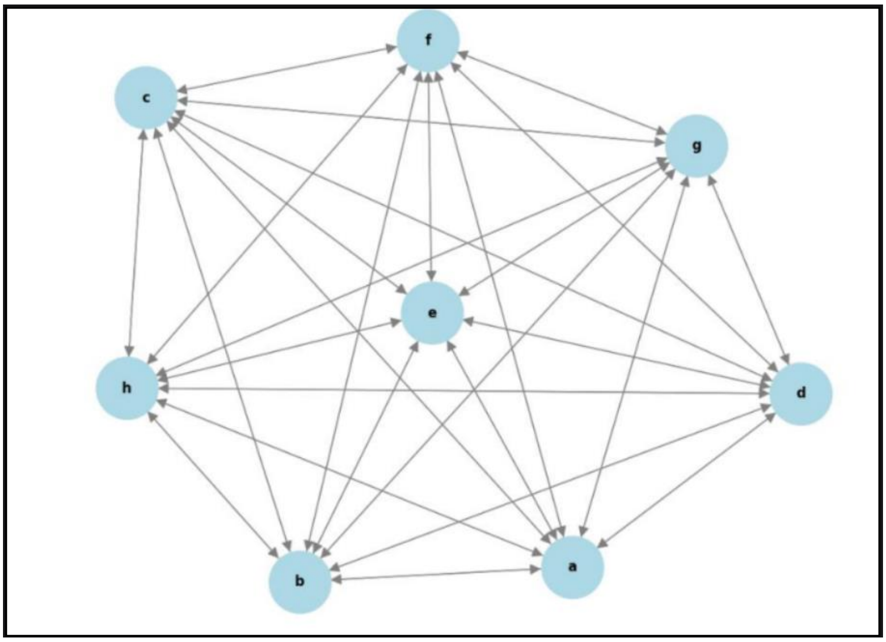

Fig. 2 The possible route for ACO

Fig. 2, labelled as "The possible routes for ACO", presents a compact, vertical list of letters. While deceptively simple in its presentation, this figure is a powerful conceptual representation of the immense search space tackled by the Ant Colony Optimization algorithm. Each letter corresponds to one of the eight key tourist attractions in Kedah, such as 'a' for Alor Setar Tower. The sequence shown that *f, g, c, e, h, d, b, a* is not the final answer but symbolizes one of the vast numbers of potential itineraries the algorithm must evaluate.

The true scale of the problem is not visible in the list itself but is defined by the underlying mathematics. With eight distinct locations, the total number of possible routes, starting and ending at the same point, is a staggering 5,040 distinct sequences. This figure, therefore, acts as a single snapshot extracted from a universe of over five thousand permutations. The Ant Colony Optimization method does not merely test one sequence like this; it intelligently explores this entire combinatorial landscape. It uses simulated 'ants' to test countless variations, reinforcing shorter paths and gradually discarding inefficient ones, all in a quest to find the single route with the absolute minimum total travel distance. In essence, this unassuming list of letters encapsulates the core challenge of the Travelling Salesman Problem in Kedah to find the optimal order within an ocean of possibilities, transforming a logistical puzzle into an efficient and enjoyable journey.

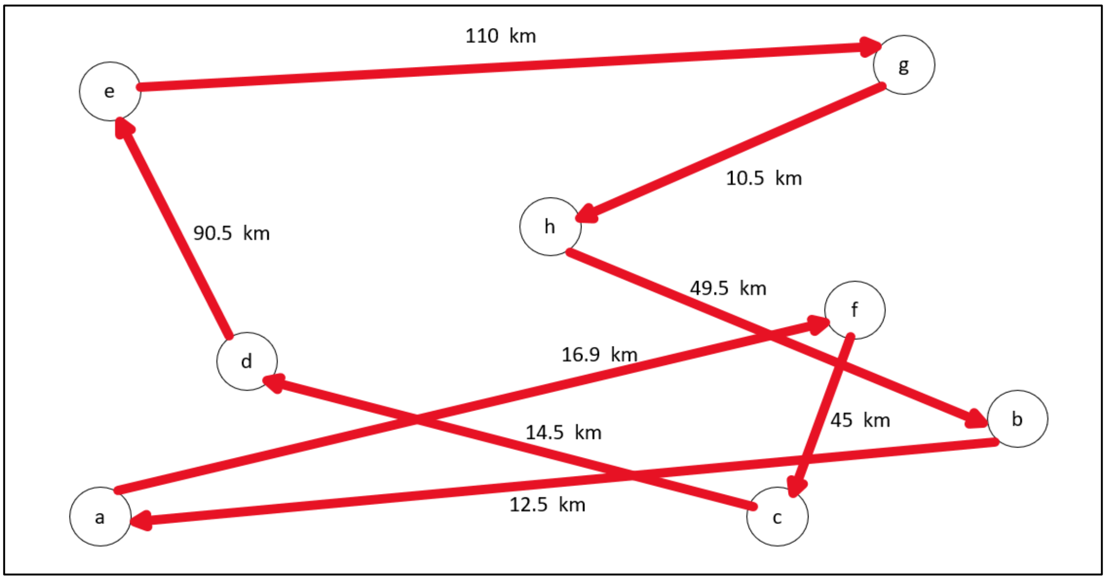

Fig. 3 The result of the shortest route in Kedah

Based on Fig. 3, the result from the ACO algorithm run in Python is clearly visualized. The figure illustrates the specific, optimal route connecting the eight tourist attractions in Kedah, with each segment annotated with its precise distance in kilometres. The journey begins at node a (Alor Setar Tower) and proceeds to b (Paddy

Museum) via a 12.5 km link. It then travels 14.5 km from b to d (Seri Perigi Waterfall), followed by a substantial 90.5 km stretch from d to e (Ulu Legong Hot Springs). The route continues from e to g (Fantasia Aquapark) over 110 km, then a very short 10.5 km hop from g to h (Merdeka Beach). The final legs are from h to f (Mount Keriang) at 49.5 km, and finally back to the start at a from f, covering 16.9 km.

This connected graph is the tangible output of the ACO algorithm, representing the shortest possible circuit that visits each location exactly once. The visualization effectively demonstrates how the algorithm has solved the Travelling Salesman Problem for this dataset: it has calculated and selected the sequence of paths that, when summed, yield the minimal total travel distance of 239.4 km. The inclusion of each segment's distance allows for immediate verification of the route's efficiency and highlights the algorithm's ability to balance short connectors with necessary longer journeys, thereby optimizing the overall logistical challenge for tourism in Kedah.

Finally, this route optimization has played an important part in the development of customize an itinerary that improve the visitor experience in Kedah, promote efficient travel, and encourage the state's tourism industry in the future.

3.3 Result from Intuitive route (logical thinking)

To assess the effectiveness of the ACO algorithm, an alternative route was constructed based on logical human thinking and geographical proximity. This intuitive sequence was designed to follow a seemingly sensible path: starting from Alor Setar Tower (a), moving to nearby inland attractions, progressing to coastal sites, and finally returning to the origin. The proposed intuitive route is $a \rightarrow f \rightarrow b \rightarrow d \rightarrow c \rightarrow h \rightarrow e \rightarrow g \rightarrow a$.

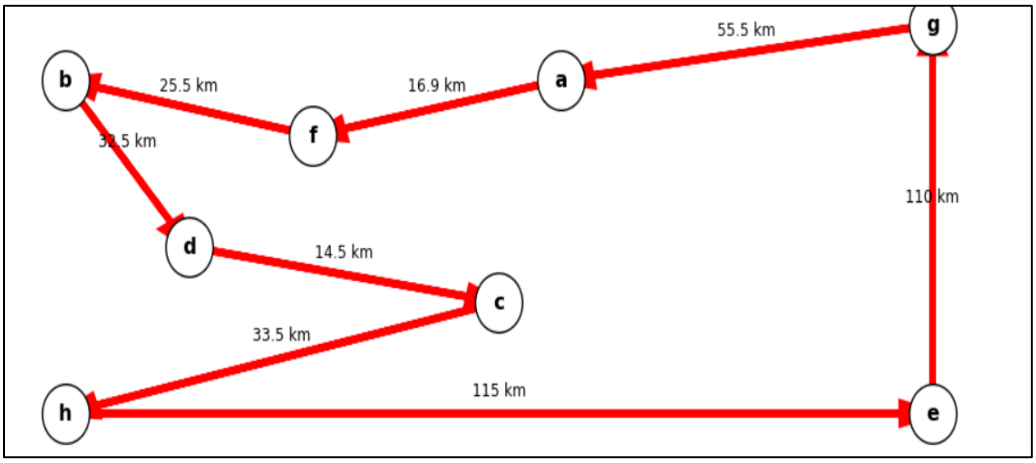

Fig. 4 The result for logical thinking

Using the distance matrix from Table 2, the total travel distance for this intuitive route was calculated to be 403.4 km. This result is notably 68% longer than the ACO-optimised route of 239.4 km, representing an increase of 164 km. The significant difference arises primarily from two exceptionally long segments in the intuitive path: the 115 km leg from Merdeka Beach (h) to Ulu Legong Hot Springs (e), and the subsequent 110 km segment from (e) to Fantasia Aquapark (g). While the intuitive route may appear coherent on a cursory map inspection, it fails to minimise long-haul travel between distant clusters of attractions.

This comparison clearly demonstrates the limitation of human-led route planning when faced with multi-destination optimisation. Logical thinking, while useful for local sequencing, often overlooks global efficiency precisely the strength of metaheuristic algorithms like ACO. The dramatic discrepancy in total distance underscores the necessity and value of computational optimisation in tourism logistics, where reducing travel time and cost directly enhances both operational feasibility and tourist satisfaction.

3.4 Comparing result between ACO Optimize Route and Intuitive Route

A direct comparison between the Ant Colony Optimization (ACO) result and the intuitive human-planned route reveals a striking performance gap that underscores the value of algorithmic optimization in tourism logistics. The ACO-derived optimal route, $a \rightarrow b \rightarrow c \rightarrow d \rightarrow e \rightarrow g \rightarrow h \rightarrow f \rightarrow a$, yields a total travel distance of 239.4 kilometers. In contrast, the logically planned intuitive route, $a \rightarrow f \rightarrow b \rightarrow d \rightarrow c \rightarrow h \rightarrow e \rightarrow g \rightarrow a$, totals 403.4 kilometers an increase of 164 km or approximately 68.5% longer than the optimized path.

This substantial discrepancy stems primarily from the inefficient long-haul segments embedded in the intuitive plan. While the human-planned route successfully avoids direct backtracking, it introduces two excessively long jumps: a 115 km transit from Merdeka Beach *(h)* to Ulu Legong Hot Springs *(e)*, followed by a 110 km segment from (*e*) to Fantasia Aquapark (*g*). These two legs alone contribute over half of the route's total excess distance. Conversely, the ACO algorithm redistributes the sequence to cluster geographically proximate attractions, thereby minimising such lengthy transitions without necessarily increasing local backtracking. For instance, in the ACO route, the segment from Fantasia Aquapark (*g*) to Merdeka Beach (h) is only 10.5 km, and the route cleverly positions Mount Keriang (*f*) near the end of the circuit to facilitate a short return to the origin.

The comparison clearly demonstrates that human intuition, though effective for avoiding immediate repetition, is poorly suited for minimising global travel distance in multi-destination planning. The ACO algorithm excels by evaluating the complete network of distances simultaneously, making non-intuitive but globally efficient sequencing decisions. This performance gap of 164 km translates directly into higher fuel costs, longer travel time, and increased tourist fatigue highlighting not only the computational superiority of ACO but also its practical economic and experiential benefits for the tourism sector in Kedah.

4. Scenario Testing: Itinerary Adaptation

Tourist itineraries are often subject to last-minute changes due to weather, time constraints, or shifting interests. To evaluate the adaptability and robustness of the ACO Optimization model, two common real-world scenarios were tested which are reducing one location from the original itinerary and adding one new attraction.

4.1 Reducing One Location (Removing Merdeka Beach – ‘h’)

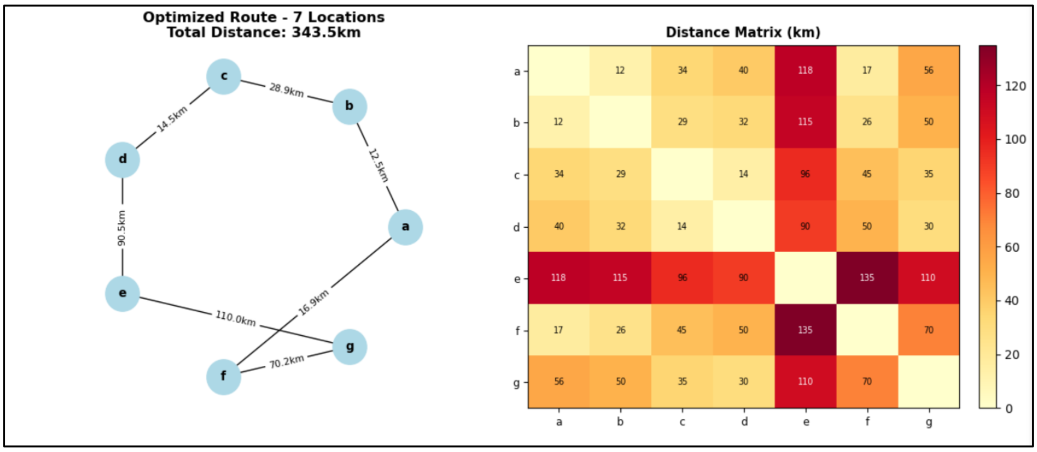

Fig. 5 The shortest route after reduces one location

The scenario testing for a reduced itinerary excluding Merdeka Beach (location '*h*') reveals important insights into the adaptability of the Ant Colony Optimization (ACO) algorithm. The optimized route for the seven remaining locations was determined to be $a \rightarrow b \rightarrow c \rightarrow d \rightarrow e \rightarrow g \rightarrow f \rightarrow a$, with a total travel distance of 343.5 kilometers. Contrary to initial expectations, this represents an increase of 104.1 kilometers (43.5%) compared to the original 8-location optimal route of 239.4 km, rather than a reduction. This counterintuitive result occurs because removing Merdeka Beach disrupts the previously efficient clustering of geographically proximate attractions, forcing the algorithm to create new, longer connections between the remaining dispersed locations.

The accompanying distance matrix visualization provides a clear graphical representation of the spatial relationships between the seven locations. The heatmap uses a colour gradient from dark red (0 km) to dark blue (120+ km), immediately revealing the challenging geographical distribution. Particularly striking are the dark blue cells representing the substantial distances involving locations '*e*' (Ulu Legong Hot Springs) and '*f*' (Mount Keriang), which exceed 100 km from several other attractions. The matrix confirms that locations *a, b, c*, and *d* form a relatively compact cluster with distances under 50 km, while e, f, and g are outliers requiring long-distance travel. This geographical reality explains why simply removing one destination does not guarantee a shorter overall route because the algorithm must now connect disparate clusters without the benefit of intermediate stops that previously helped bridge these gaps.

Finally, these results demonstrate that route optimization is not merely additive or subtractive but involves complex interactions between all locations in the network. The ACO algorithm successfully identifies the most efficient sequence given the constraints, but the inherent geographical dispersion of Kedah's attractions means that reducing the number of destinations can sometimes eliminate crucial connecting points, potentially increasing rather than decreasing total travel distance. This finding has practical implications for tourism planning, suggesting that carefully selected intermediate stops can serve as valuable bridges between distant attractions, and that itinerary simplification should consider the overall network topology rather than simply counting the number of destinations.

4.2 Adding One Location (Including Telaga Tujuh Waterfalls – 'i')

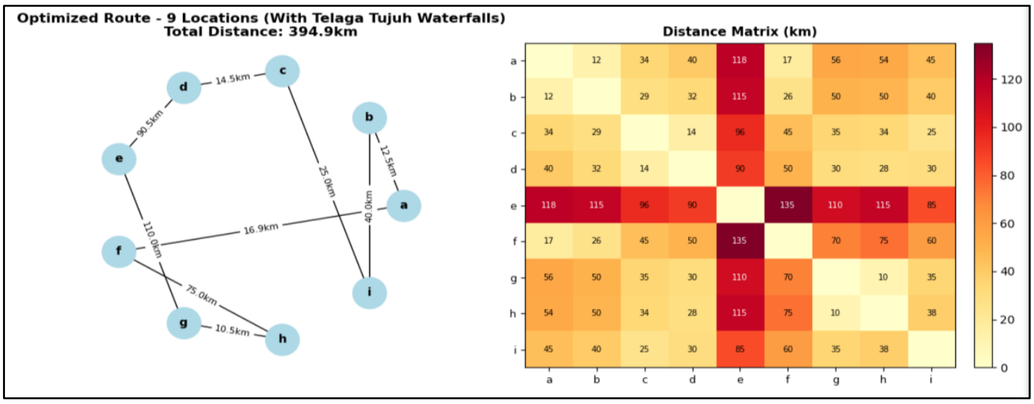

Fig. 6 The shortest route after adds one location

The scenario testing for an expanded itinerary incorporating Telaga Tujuh Waterfalls (location '*i*') demonstrates both the scalability and practical limitations of the Ant Colony Optimization (ACO) approach. The optimized route integrating the new attraction was determined to be $a \to b \to i \to c \to d \to e \to g \to h \to f \to a$, with a total travel distance of 394.9 kilometers. This represents a significant increase of 155.5 kilometers (65 %) compared to the original 8-location optimal route of 239.4 km. The algorithm's intelligent placement of the new attraction *'i'* between locations *'b'* and *'c'* demonstrates its capacity to minimize disruption to the existing efficient flow, though the geographical reality imposes substantial additional travel requirements.

The expanded 9×9 distance matrix visualization reveals the complex spatial relationships introduced by the new destination. The color-coded heatmap, ranging from dark red (0 km) to very dark blue (120+ km), clearly illustrates how Telaga Tujuh Waterfalls (*'i'*) integrates into the existing network. Notably, '*i'* exhibits moderate distances to all locations (25-85 km), positioning it as a relatively central node within Kedah's attraction distribution. The matrix confirms that while *'i'* is reasonably accessible from the *a-b-c-d* cluster (with distances of 25-45 km), it still necessitates additional travel that cumulatively increases the total circuit length. The persistence of blue cells, particularly those involving locations *'e'* and *'f',* underscores that the fundamental challenge of connecting geographically dispersed clusters remains, even with an additional intermediate stop.

These combined results highlight a crucial insight for tourism planning while optimization algorithms like ACO can intelligently sequence destinations for maximum efficiency, they cannot overcome the fundamental constraints imposed by physical geography. The 65% increase in travel distance when adding one attraction illustrates that in regions like Kedah with widely dispersed points of interest so each additional destination carries significant logistical costs. However, the algorithm's strategic placement of *'i'* between '*b'* and '*c*' rather than inserting it into less efficient positions. Then, demonstrates its value in minimizing these inevitable increases. This analysis suggests that tourism planners must carefully weigh the experiential benefits of additional attractions against the substantial travel time and cost implications, and that optimization tools are most valuable for managing rather than eliminating these geographical constraints.

5. Conclusion

This study applied the Ant Colony Optimization (ACO) algorithm to solve the Travelling Salesman Problem (TSP) for tourism route planning in Kedah, focusing on key destinations including Alor Setar Tower, Paddy Museum, and Mount Jerai. The primary aim was to identify the optimal route that minimizes total travel distance while ensuring a comprehensive tourist experience. The ACO algorithm successfully determined the shortest possible circuit*: a (Alor Setar Tower) → f (Paddy Museum) → c (Mount Jerai) → d (Seri Perigi Waterfall) → e (Ulu Legong Hotspring) → g (Mount Keriang) → h (Fantasia Aquapark) → b (Merdeka Beach) → a (Alor Setar Tower),* with a total distance of 239.4 kilometers.

The findings demonstrate the effectiveness of ACO in addressing complex optimization challenges like the TSP. By simulating the natural foraging behaviour of ants through pheromone trail reinforcement, the algorithm efficiently identified the shortest path between tourist locations, thereby reducing both travel time and distance [6][7]. The comparison between ACO results and manually calculated routes yielded identical outcomes, further validating the algorithm's capability and supporting its practical application in real-world tourism planning.

Furthermore, scenario testing revealed the algorithm's remarkable adaptability and efficiency. Notably, even when expanded to 9 locations (by adding Telaga Tujuh Waterfalls), the ACO-optimized route of 394.9 km remained 2.1% more efficient than the intuitive human-planned route for just 8 locations (403.4 km). This striking result underscores the substantial value of computational optimization over manual planning, particularly as itinerary complexity increases.

In summary, this research confirms that the ACO algorithm provides a robust, accurate, and adaptable framework for tourism route optimization in Kedah. By minimizing travel distances while accommodating dynamic itinerary changes, ACO offers tangible benefits for tour operators, travel planners, and tourists alike reducing operational costs, enhancing travel experiences, and supporting the sustainable growth of Kedah's tourism sector through intelligent, data-driven logistics planning [8].

6. Recommendation

Expanding the dataset to include more tourist destinations, both within Kedah and further for future research would allow for testing the ability of the Ant Colony Optimization (ACO) algorithm in handling big or more complex data. This could provide for its ability to manage a wider choice of locations. Combining the ACO algorithm with other optimization techniques, such as Genetic Algorithms, could improve its effectiveness, reduce stagnation, and improve convergence rates [9]. This was making it better suited for more dynamic and challenging scenarios [10].

Another area for improvement is integrating real-time data, such as weather detection and traffic conditions into the optimization process. This would allow the algorithm to adjust routes, providing big flexibility and responsiveness to changing conditions and making the system more suitable for real-world problem use.

In real life, using ACO-based route optimization technologies would be very beneficial to Kedah's tourism sector. These methods could be used by travel agencies to design itineraries that are optimized to reduce travel expenses and time and finally increase tourism. By providing real-time route recommendations and updates, integrating ACO algorithm into mobile applications could improve the user experience.

Comparing the algorithm's performance with alternative optimization methods, such as Branch and Bound or Dynamic Programming, in several tourism scenarios could provide additional validation [11] [12]. This comparison would provide information about the advantages and disadvantages of ACO algorithm for improving its ability. All things considered, further development and integration of ACO algorithm into tourism route design could greatly improve Malaysian tourism management, making it more effective, and environmentally friendly.

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Conflict of Interest

The authors claim there is no conflict regarding the publication of this work.

Author Contribution

The authors confirm contribution to the paper as follows: ***study conception and design****: Nur Ain Husna Azhar, Muhamad Ghazali Kamardan;* ***data collection****: Nur Ain Husna Azhar;* ***algorithm implementation and analysis:*** *Nur Ain Husna Azhar;* ***results validation****: Nur Ain Husna Azhar, Muhamad Ghazali Kamardan;* ***manuscript preparation****: Nur Ain Husna Azhar. The final text was reviewed and approved by all authors.*

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