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HISTORICAL TOURISM ITINERARY PLANNING IN SONGKHLA PROVINCE USING HEURISTIC METHOD

(Perancangan Jadual Perjalanan Pelancongan Sejarah di Wilayah Songkhla Menggunakan Kaedah Heuristik)

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ABSTRACT

Optimizing historical tourism itineraries in Songkhla Province presents a significant combinatorial challenge, owing to its geographically dispersed attractions and a lack of systematic planning. This research, therefore, proposes the development of a routing model by comparing the efficiency of two heuristic methods: the Nearest Neighbor Heuristic (NNH) and the Clarke and Wright Savings Algorithm (SA). The objective was to create multi-day itineraries covering 20 significant attractions, under the constraint of an 8-hour maximum daily travel duration. The findings indicate that the Savings Algorithm (SA) demonstrates clearly superior performance, yielding a shorter total travel distance (635.4 km compared to 648.9 km) and allocating attractions within each route far more symmetrically. Therefore, the SA is a more suitable tool for stakeholders to implement in actual itinerary planning to reduce costs, enhance the tourist experience, and promote sustainable tourism in Songkhla.

Keywords: heuristic method; tourism route planning; historical tourism

ABSTRAK

Pengoptimuman jadual perjalanan pelancongan sejarah di Wilayah Songkhla merupakan satu cabaran kombinatorial yang signifikan, disebabkan oleh tarikan-tarikannya yang berselerak dari segi geografi dan kekurangan perancangan yang sistematik. Justeru, kajian ini mencadangkan pembangunan sebuah model laluan dengan membandingkan kecekapan antara dua kaedah heuristik: Heuristik Jiran Terdekat (NNH) dan Algoritma Penjimatan Clarke dan Wright (SA). Objektifnya adalah untuk mewujudkan jadual perjalanan berbilang hari yang merangkumi 20 tarikan signifikan, di bawah kekangan tempoh perjalanan harian maksimum selama 8 jam. Dapatan kajian menunjukkan bahawa Algoritma Penjimatan (SA) menunjukkan prestasi yang jelas lebih unggul, dengan menghasilkan jumlah jarak perjalanan yang lebih pendek (635.4 km berbanding 648.9 km) serta mengagihkan tarikan dalam setiap laluan dengan jauh lebih seimbang. Oleh itu, SA merupakan alat yang lebih sesuai untuk dilaksanakan oleh pihak berkepentingan dalam perancangan jadual perjalanan yang sebenar bagi mengurangkan kos, meningkatkan pengalaman pelancong, dan mempromosikan pelancongan lestari di Songkhla.

Kata kunci: kaedah heuristik; perancangan laluan pelancongan; pelancongan sejarah

1. Introduction

Historical tourism is a form of travel to places of historical, traditional, social, and cultural value. This includes locations that embody the memories and bonds of people from the past, which are then transmitted to the present generation for enjoyment, to foster an appreciation for the value of these sites, and to cultivate a sense of responsibility for the preservation of historical heritage, with local communities participating in tourism management (Intamano & Visuthismajarn 2019). Songkhla Province is one such area of significant historical and cultural importance, featuring several key attractions such as Songkhla Old Town, Wat Matchimawat, and the Khao Nam Khang Historical Tunnel, which reflect the region's cultural and historical diversity. However, planning efficient tourist routes in an area with numerous and geographically dispersed attractions is a challenge (Lim *et al.* 2019; Sirirak & Pitakaso 2013; Zhen & Gao 2017), as it requires consideration of various factors such as distance, opening and closing times of sites, and the interests of tourists (Lim *et al.* 2019; Wu *et al.* 2017; Zheng *et al.* 2022). To address this issue, several research studies have proposed the use of heuristic methods for tourist route planning, which can effectively find optimal solutions under various constraints (Sirirak & Pitakaso 2013; Göncü 2025; Sarawan & Khumla 2025; Rahma *et al.* 2020).

The application of heuristic methods in planning historical tourism routes can help solve such problems by utilizing analytical and planning techniques that are adaptable to the needs of tourists and various constraints, such as time, budget, and personal interests. This aligns with international approaches to efficient tourist route planning (Wu *et al.* 2017). Furthermore, the use of heuristic methods can enhance historical tourism in Songkhla Province by designing routes that are tailored to tourist preferences (Zheng *et al.* 2022) and by promoting community participation in the tourism process. This will contribute to the conservation of the area's culture and history and promote sustainable tourism (Choomrit *et al.* 2021; Intamano & Visuthismajarn 2019; Pitakaso *et al.* 2024; Winyangkun *et al.* 2014).

The planning of historical tourism routes in Songkhla Province using heuristic methods is a topic that has not been sufficiently studied. Although there has been research on general tourist route planning using heuristics in various contexts, such as urban tourism or holiday planning (Göncü 2025; Rani *et al.* 2018; Mangini *et al.* 2021), a literature review reveals a significant gap in the application of these computational optimization techniques specifically to historical tourism. This gap is particularly critical in an area like Songkhla Province, which possesses diverse and valuable historical sites like Songkhla Old Town, Wat Phakho, and Khao Tang Kuan (Zhen & Gao 2017). However, the management and planning of tourist routes in this area still lack a systematic approach and adequate community participation (Intamano & Visuthismajarn 2019). This research article, therefore, focuses on developing a system for planning historical tourism routes in Songkhla Province by comparing the efficiency of two heuristic methods: the Nearest Neighbor Heuristic (NNH) and the Savings Algorithm (SA). The objective is to identify and confirm which method performs most effectively for historical tourism route planning in Songkhla Province. The results of this comparison will lead to practical recommendations that can enhance travel efficiency, promote community involvement, and support sustainable tourism, aligning with the broader goals of cultural and historical preservation in the region.

Moreover, planning historical tourism routes must also consider specific factors such as the historical significance of the sites, accessibility, and the availability of infrastructure, which differ from general tourism planning (Intamano & Visuthismajarn 2019). This research is therefore crucial in filling a knowledge gap in the application of heuristic methods within the context of historical tourism in Songkhla Province. Consequently, planning historical tourism routes in Songkhla using heuristic methods presents a promising approach to increase tourism efficiency and foster the conservation of the area's culture and history, aligning with current tourism trends that emphasize community participation and sustainability.

2. The Application of Heuristic Methods in Historical Tourism Route Planning

Historical tourism route planning is the process of efficiently organizing travel to sites of cultural and historical value, taking into account constraints such as time, distance, and the needs of tourists (Lim *et al.* 2019). Precise methods for this type of route planning are often classified as Combinatorial Optimization Problems, such as the Travelling Salesman Problem (TSP) (Lawler *et al.* 1991) or the Vehicle Routing Problem (VRP), for which finding the optimal solution is not computationally feasible in a reasonable amount of time (Göncü 2025; Sarawan & Khumla 2025). For this reason, the application of Heuristic Methods has become a widely popular alternative for solving these problems, as they can find near-optimal solutions within a limited timeframe (Göncü 2025; Rahma *et al.* 2020).

This research presents the application of two heuristic methods-the Nearest Neighbor Heuristics (NNH) method and the Savings Algorithm (SA)-to design historical tourism routes within Songkhla Province, an area where cultural and historical attractions are dispersed across various locations, both in the old town and its suburbs. Examples include the Songkhla National Museum, Wat Matchimawat, the Songkhla History Hall, and the Chinese community along Nakhon Nok Road.

2.1. *Nearest Neighbor Heuristics (NNH)*

The Nearest Neighbor Heuristic (NNH) method is a technique that employs a greedy approach (Khamsaen *et al*. 2018; Nannar *et al*. 2023; Sawangyat 2018). It begins at a designated starting point, such as a hotel or tourist service center, and then selects the nearest unvisited location (Göncü 2025; Sarawan & Khumla 2025; Rahma *et al.* 2020). This process is repeated until all locations have been visited or time constraints have been met. The procedure for creating a tourist route using the Nearest Neighbor method is as follows:

(1) Establish a starting point for the journey as a reference point for the route search (e.g., hotel, bus terminal, or airport). Then, find the attraction closest to this reference point.
(2) Select the attraction closest to the reference point and incorporate it into the main route. Then, designate that attraction as the next reference point.
(3) From the last reference point on the route, find the nearest attraction that has not yet been routed. Evaluate whether adding this new attraction would cause the total tour time to exceed the predefined limit. If the total time is not exceeded, merge the selected attraction into the main route.
(4) If adding the attraction causes the total tour time to be exceeded, the current route is finalized. Then, check if any attractions remain unrouted. If so, repeat steps (1), (2), and (3) to create a new route, continuing until all attractions have been included.

This method has the advantages of being easy to implement and computationally fast (Sarawan & Khumla 2025; Rahma *et al.* 2020), especially when dealing with a large number of attractions and the need to provide preliminary planning for tourists with limited time and information. In the context of historical tourism, this method is suitable as tourists often tend to choose routes based on geographical proximity, such as starting at a museum and walking to a nearby temple or community. The use of NNH reflects the actual experiential decision-making behavior among tourists.

2.2. *Saving Algorithm (SA)*

Proposed by Clarke and Wright (Clarke & Wright 1964), the Savings Algorithm (SA) is one of the most popular and highly effective heuristic techniques for the VRP (Clarke & Wright 1964; Gendreau & Potvin 2021; Pitakaso 2013). The core principle is to start by assuming that each tourist location is visited via a separate route from a depot. Then, pairs of locations are iteratively merged, prioritizing the pair that yields the highest "saving" in travel distance. The analysis steps are as follows:

(1) Select one starting point or depot for the tour. This initially creates a separate route from the depot to each attraction.
(2) Calculate the savings in transportation time, distance, or cost (Saving Cost) using Eq. (1):

$$S_{ij} = D_{0i} + D_{0j} - D_{ij} \quad (1)$$

where:

i, j represent tourist attractions, and 0 represents the starting point or depot.
S_{ij} is the travel distance saved by linking attractions i and j.
D_{0i} is the travel distance from the depot to attraction i.
D_{0j} is the travel distance from the depot to attraction j.
D_{ij} is the travel distance from attraction i to attraction j.

(3) Sort the savings values (S_{ij}) in descending order (from largest to smallest).
(4) Form a route by linking the pair of attractions i and j that has the highest savings value, S_{ij}.
(5) Repeat this process until all attractions have been assigned to a route, subject to the constraints of the tour, such as ensuring the total time for each route does not exceed the planned duration (Sueni 2020). As shown in Figure 1, the Savings Algorithm is a well-accepted theory for managing tour routes. The concept is straightforward: the saving value (S_{ij}) represents the distance that can be reduced between any two attractions. A high saving value signifies a substantial potential reduction in travel distance.

This method facilitates the appropriate clustering of nearby attractions, leading to routes that are continuous and non-redundant. For tourism routes in Songkhla Province, the SA allows for well-structured visit planning, potentially by grouping attractions within the same zone, such as the cluster of temples in the old town, the group of historic houses with Sino-European architecture, or the group of arts and culture museums (Zhen & Gao 2017; Patil & Jaybhaye 2023; Zhang *et al*. 2020). This is particularly suitable for designing themed tour programs, such as a "100 Years of Songkhla's Past Tour."

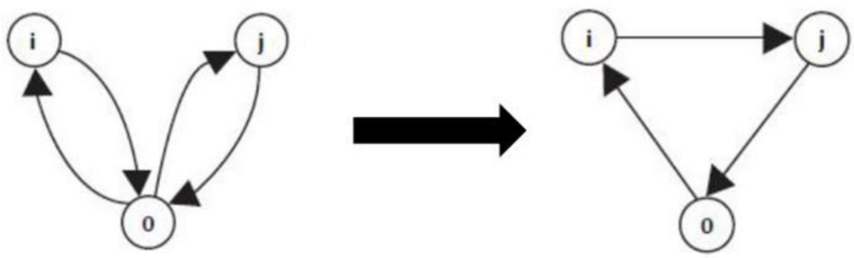

Figure 1: Conceptual of savings value

2.3. *Application in the context of Songkhla Province*

The use of these two heuristic methods in the Songkhla Province area constitutes a suitable case study. This is due to the city's physical characteristics, which include tourist attractions dispersed over short and medium distances, a relatively dense road network in the urban core that connects to the suburbs, and time-based constraints such as the operating hours of certain venues. Heuristic methods can flexibly incorporate these constraints into the route planning process.

Therefore, the application of heuristic methods in planning historical routes is a high-potential approach for enhancing the quality of the tourist's journey. It not only helps to reduce travel distance and time but also supports planning that aligns with the cultural and learning experiences of the tourist.List may be presented with each item marked by bullets and numbers. The conceptual framework for solving the historical tourism itinerary planning problem is shown in Figure 2.

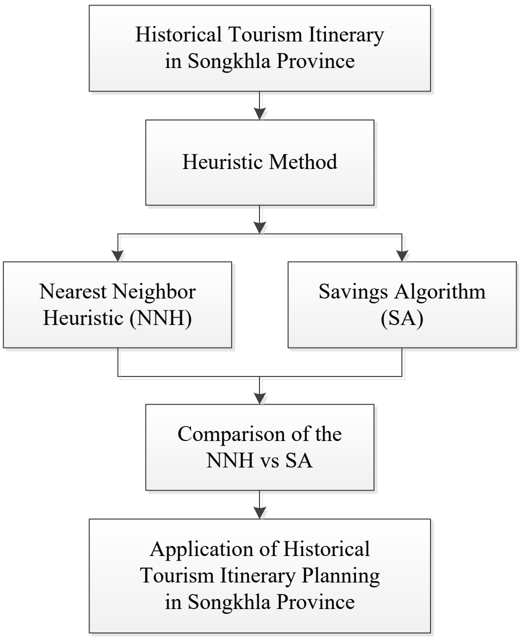

Figure 2: Conceptual framework

3. Results and Discussion

3.1. *Data collection*

This study focuses on developing an optimal routing model for historical tourism in Songkhla Province. The dataset comprises 20 significant historical sites, selected based on their current popularity. For the purpose of this study, the Laguna Grand Hotel & Spa Songkhla (H0) serves as the designated depot (the starting and ending point for all routes), chosen due to its status as a popular accommodation choice for tourists. The hotel is located at geographic coordinates 7.1255° N, 100.5572° E.

The geographic coordinates (latitude/longitude) and the estimated visit duration for each of the 20 historical attractions are detailed in Table 1. To calculate travel times between locations, the model assumes transportation is by private or rental car at an average speed of

90 km/h. The resulting distance matrix, which provides the travel distances between all pairs of locations (inter-attraction and attraction-to-depot), is presented in Table 2.

3.2. *Application of the Nearest Neighbor Heuristic (NNH)*

In this study, the Nearest Neighbor Heuristic (NNH) is employed to construct the tourism routes. The routing process operates under a primary constraint: the total duration of any single route, comprising both cumulative travel time and on-site visit durations, must not exceed 480 minutes (equivalent to an 8-hour day trip). The NNH algorithm functions by iteratively processing a pre-calculated travel time matrix and the specified visit time for each attraction. The procedural steps of the NNH algorithm, as implemented in this research, can be formally outlined as follows:

1) Notation

Let $V = \{0, 1,..., n\}$ be the set of all locations, where node 0 represents the starting point (depot), and $C = V \setminus \{0\}$ is the set of tourist attractions. Let the following parameters be defined:

d_{ij} : The distance or travel cost between location i and j. This is used for the "nearest" selection criterion.

t_{ij} : The travel time between location i and j.

s_i : The service time (visiting duration) required at attraction $I \in C$. We assume $s_0 = 0$.

$T_{\max}$: The maximum allowable duration for a single tour route, which in this case is specified as 480 minutes**.**

The algorithm constructs a route, which is an ordered sequence of locations. Let $P_k = (p_0, p_1,..., p_k)$ be the partial route after k steps, where p_k is the last added location. Let U_k be the set of unvisited attractions at step k.

Table 1: Coordinates of historical tourist attractions in Songkhla Province

Code	Tourist attraction	Coordinates (Latitude, Longitude)	Visiting time (minutes)
TA1	Wat Laem Bo Tho	7.54290323602401, 100.30084046443473	30
TA2	Wat Ek Choeng Sae	7.63762617609212, 100.33361744909297	30
TA3	Wat Phakho	7.60138255658239, 100.39213149512429	45
TA4	Wat Ja Thing Phra	7.47467340270290, 100.43924562767184	40
TA5	Wat Suwannakhiri	7.19521076441707, 100.57853576630893	30
TA6	Wat Khongkhawadi (Wat Pak Bang)	7.18900307891733, 100.40428702211622	30
TA7	Wat Khongkhaliep	7.01985315559553, 100.41253476259420	30
TA8	Phra Yai Plak Kha	6.88457803686984, 100.41409107903985	30
TA9	Songkhla Central Mosque (Dinnul Islam)	7.01389261954571, 100.46564522767486	30
TA10	Phra Maha That Chedi Traiphop Traimongkhon	7.00525546744017, 100.51639832397670	45
TA11	Wat Hat Yai Nai	7.00360856841674, 100.45423047742600	30
TA12	Street Art in Songkhla Old Town	7.19537563214922, 100.58999283805554	60
TA13	Khao Tang Kuan	7.21046718391510, 100.58961680069763	60
TA14	Wat Matchimawat	7.19603678255522, 100.59348794491808	45
TA15	Khao Kao Seng	7.18309359978785, 100.61764270196703	40
TA16	Wat Khuat	6.81893106481225, 100.65528335281931	30
TA17	Khao Nam Khang Historical Tunnel	6.57429853259277, 100.57578220439580	60
TA18	Wat Tham Khao Rup Chang	6.71544424934970, 100.27768713933163	40
TA19	Wat Pak Ao Suwannaram	6.96166279530552, 100.56873565650348	30
TA20	Luang Pho Thuad Lin Dam Thung Meru	6.96672789173309, 100.55781963747127	20

Table 2: Distance matrix between tourist attractions (unit: kilometers)

Code	Ho	TA1	TA 2	TA 3	TA4	TA5	TA6	TA7	…	TA19	TA20
Ho	0.00	76.8	72.3	61.3	45.5	16.8	34.9	25.0	…	26.6	24.8
TA1	76.9	0.00	13.5	15.8	29.9	69.2	77.8	102.7	…	98.5	96.7
TA2	72.3	13.4	0.00	10.4	40.7	64.6	73.1	98.0	…	93.8	92.1
TA3	61.4	15.8	10.4	0.00	29.8	53.7	62.3	87.2	…	83.0	81.2
TA4	49.1	31.3	26.8	15.8	0.00	41.4	50.0	74.9	…	70.7	69.0
TA5	15.2	68.0	63.5	52.5	36.7	0.00	41.0	40.9	…	36.8	35.0
TA6	27.1	77.7	73.2	62.2	46.4	42.2	0.00	28.1	…	48.8	49.1
TA7	24.2	102.1	97.6	86.6	70.8	42.1	27.6	0.00	…	21.2	21.6
…	…	…	…	…	…	…	…	…	…	…	…
TA19	26.0	97.9	93.3	82.4	66.6	37.8	48.1	21.6	…	0.00	2.7
TA20	26.2	98.1	93.5	82.6	66.8	38.1	47.7	21.2	…	2.3	0.00

2) Algorithm

The Nearest Neighbor heuristic can be described by the following iterative procedure:

Step 0: Initialization

(1) Start at the depot: The initial route is $P_0 = (p_0)$, where $p_0 = 0$.
(2) The set of unvisited attractions is $U_0 = C$.
(3) The initial elapsed time is $\tau(P_0) = 0$.
(4) Set the step counter $k = 0$.

Step 1: Selection of the next location

At each step k, from the current location p_k, select the nearest unvisited attraction j^*. The selection is determined by solving the optimization problem shown in Eq. (2).

$$j^* = \arg\min_{j \in u_k} \{d_{pk,j}\} \tag{2}$$

This expression states that j^* is the attraction j from the set of unvisited attractions (U_k) that minimizes the travel distance from the current location p_k.

Step 2: Feasibility check

Before adding j^* to the route, verify that its inclusion does not violate the maximum time constraint. The projected total time must satisfy the constraint shown in Eq. (3).

$$\tau(P_k) + t_{pk,j^*} + s_{j^*} \le T_{\max} \tag{3}$$

where $\tau(P_k)$ is the cumulative time of the current partial route P_k, calculated in Eq. (4).

$$\tau(P_k) = \sum_{i=0}^{k-1} (t_{p_i,p_{i+1}} + s_{p_i}) \tag{4}$$

Step 3: Route update

(1) If the feasibility condition in step 2 is met:
- Append the new location to the route: $P_k + 1 = (p_0, ..., p_k, j^*)$.
- Update the set of unvisited attractions: $U_k + 1 = U_k \setminus \{j^*\}$.
- Update the elapsed time: $\tau(P_k + 1) = \tau(P_k) + t_{pk}, j^* + s_{j^*}$.
- Increment the step counter $k \leftarrow k + 1$ and return to step 1.

(2) If the feasibility condition is not met or if U_k is empty:

- The current route cannot be extended. Finalize the route by returning to the depot. The complete route is $P_{\text{final}} = (p_0, ..., p_k, 0)$.
- The algorithm for this route terminates.

The application of the Nearest Neighbor Heuristic (NNH) for historical tourism route planning in Songkhla Province yielded four distinct routes, systematically sequencing all 20 attractions. The comprehensive travel plan covers a total distance of 648.9 km and requires a total duration of 1,489 minutes (approximately 24.8 hours). This total time comprises 734 minutes of travel and 755 minutes for on-site visitation, as detailed in Table 3 and Figure 3.

Table 3: Nearest Neighbor Heuristic (NNH) results for itinerary planning

Trip	Visiting sequence	Number of tourist attractions	Distance (km)	Travel time (min)	Visiting time (min)	Total time (min)
1	0-14-12-13-15-9-11-7-19-0	8	108.4	134	325	459
2	0-5-4-3-2-1-6-0	6	198.0	221	205	426
3	0-20-10-8-18-17-0	5	236.0	270	195	465
4	0-16-0	1	106.5	109	30	139
Total		20	648.9	734	755	1,489

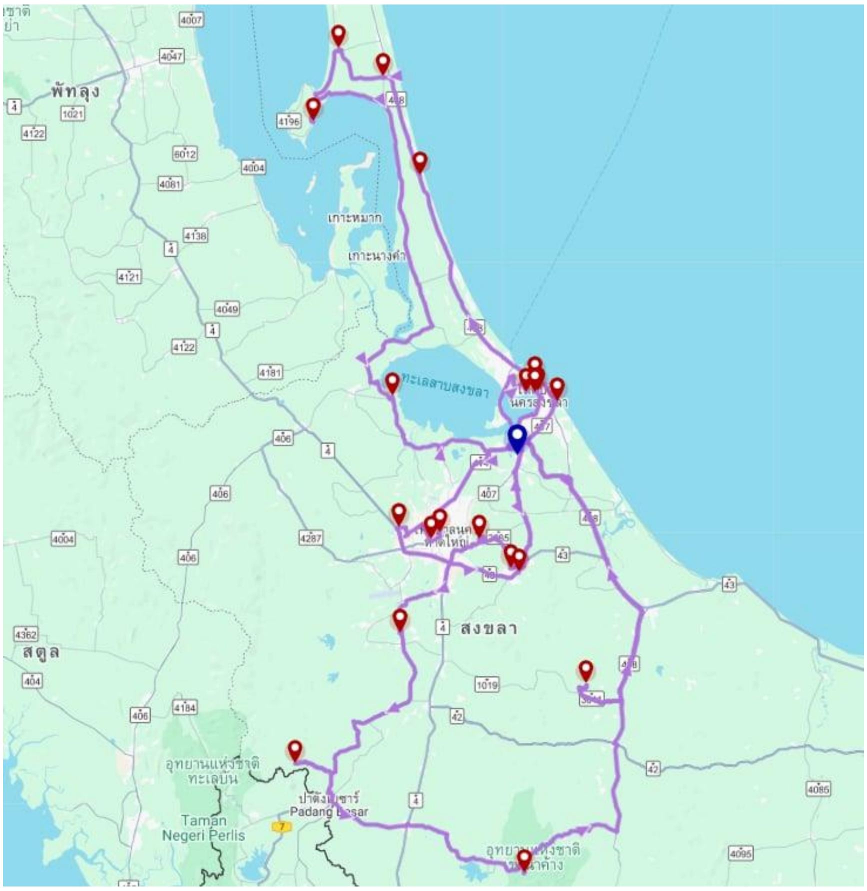

Figure 3 : Planning historical tourism routes with the HHN method.

3.3. *Application of the Saving Algorithm (SA)*

It is one of the most popular and highly effective heuristic techniques for the Vehicle Routing Problem (VRP). The core principle of this algorithm is to start from the assumption that each tourist attraction is visited via a completely separate route (a round trip from the depot). Subsequently, pairs of locations are iteratively merged into the same route, prioritizing the pair that yields the highest "saving" in travel distance. The analysis steps are as follows:

1) Savings calculation

The heart of this algorithm is the calculation of the saving value, which represents the reduction in distance (or time/cost) achieved when two attractions are linked together, instead of being served by separate trips from the depot. The saving value (S_{ij}) is calculated using Eq. (1).

2) Algorithmic procedure

The process of constructing tour routes using the Savings Algorithm can be formally summarized as follows:

Step 1: Initialization

Create n initial routes for n attractions. Each route consists of a direct trip from the depot (node 0) to an attraction (i) and immediately back to the depot, i.e., the route 0→i→0.

Step 2: Savings calculation and sorting

(1) Calculate the saving value S_{ij} for all possible pairs of attractions (i, j) using Eq. (1).

(2) Create a Savings List and sort it in descending order (from the largest value to the smallest).

Step 3: Iterative merging

Process the saving values S_{ij} sequentially from the sorted list. For each value S_{ij}, consider merging the routes containing nodes i and j, subject to satisfying all of the following Feasibility Conditions:

Condition 3.1: Nodes i and j must belong to two different routes.

Condition 3.2: Nodes i and j must be endpoint nodes of their respective routes (i.e., they are directly connected to the depot).

Condition 3.3: The merged route must not violate the problem's constraints. For example, the total time of the new route (comprising travel and visit times) must not exceed the predefined limit ($T_{route} \leq T_{max}$).

Step 4: Route update

If all conditions in Step 3 are met, merge the two routes by removing their links to the depot (e.g., i→0 and 0→j) and creating a new link between nodes i and j instead (e.g., ...→i→j→...).

Step 5: Termination

Repeat steps 3 and 4 until the savings list has been fully processed or no more feasible merges are possible. The result is an optimized set of tour routes.

The application of the Saving Algorithm for historical tourism route planning in Songkhla Province yielded four distinct routes, systematically sequencing all 20 attractions. The comprehensive travel plan covers a total distance of 635.4 km and requires a total duration of 1,486 minutes (approximately 24.8 hours). This total time comprises 731 minutes of travel and 755 minutes for on-site visitation, as detailed in Table 4 and Figure 4.

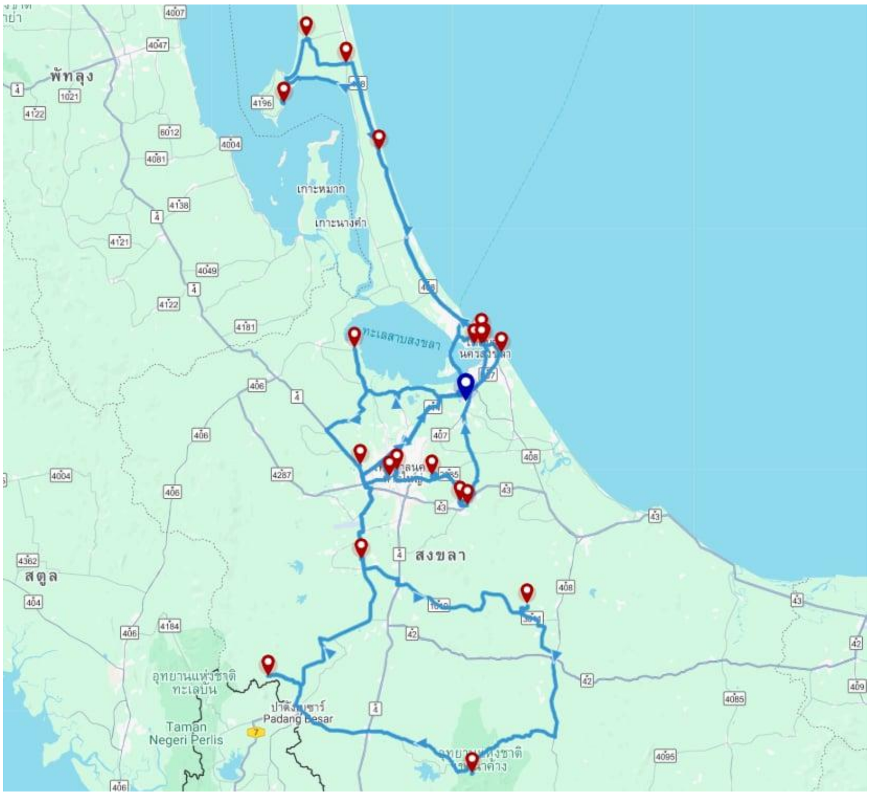

Figure 4 : Planning historical tourism routes with the SA method

Table 4 : Savings algorithm (SA) results for itinerary planning

Trip	Visiting sequence	Number of tourist attractions	Distance (km)	Travel time (min)	Visiting time (min)	Total time (min)
1	0-1-2-3-4-5-0	5	187.1	188	175	363
2	0-6-7-11-12-13-14-15-0	7	127.6	159	295	454
3	0-8-16-17-18-0	4	247.5	283	160	443
4	0-9-10-19-20-0	4	73.2	101	125	226
Total		20	635.4	731	755	1,486

3.4. *Comparison of the NNH and SA routing results*

For the quantitative analysis, a comparative graphical analysis using bar charts was conducted to evaluate the Nearest Neighbor Heuristic (NNH) and the Saving Algorithm (SA). The comparison is based on three key metrics for each generated route: (1) the number of locations visited, (2) the total route duration (in minutes), and (3) the total route distance (in kilometers). These comparative results are illustrated in Figure 5 - Figure 7.

Figure 5 reveals that while the Nearest Neighbor (NNH) method creates a single route with a high density of up to 8 locations, the Saving Algorithm (SA) provides a more consistent workload distribution. The SA routes are more evenly structured, each containing 4 to 7 sites. Consequently, the SA balanced approach is more suitable for practical implementation in tour planning.

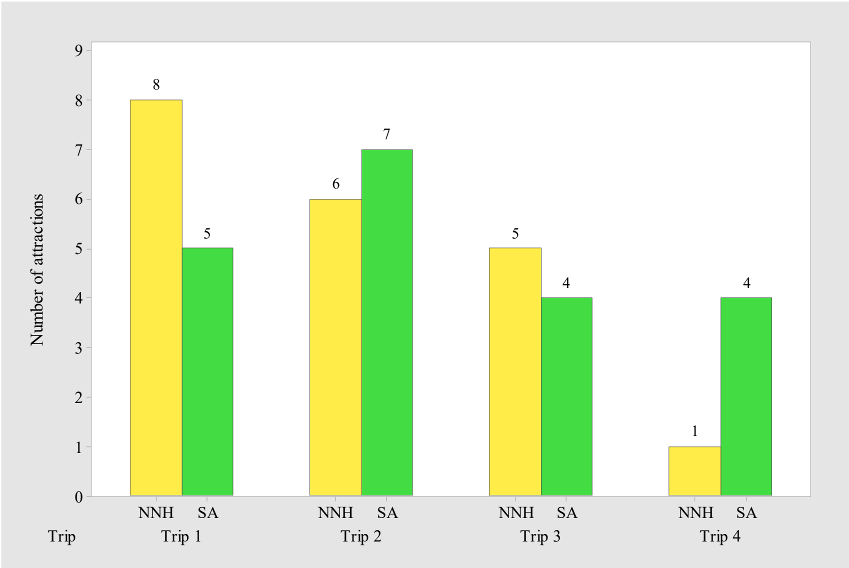

Figure 5 : Number of attractions per trip

Figure 6 illustrates that while both methods adhere to the 480-minute maximum time constraint per route, the Saving Algorithm (SA) generally yields routes with shorter total durations. This is particularly evident when comparing the fourth route from each method. Although the Nearest Neighbor (NNH) route is shorter at 139 minutes versus the SA's 226 minutes, the NNH route includes only a single attraction, rendering it highly inefficient. This demonstrates that the Saving Algorithm utilizes time more effectively, offering greater value and efficiency in the overall plan.

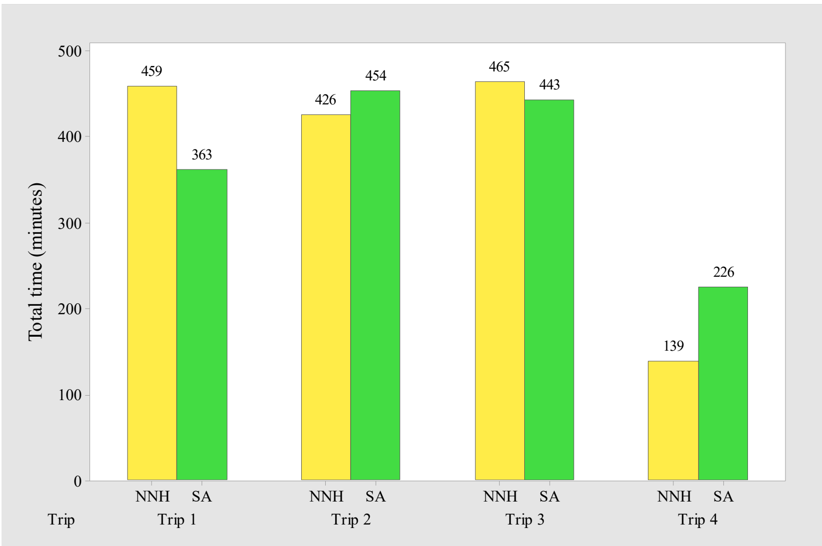

Figure 6 : Comparison of total duration per itinerary

Figure 7 indicates that the Saving Algorithm (SA) is more effective at distance optimization, producing a total travel distance of 635.4 km. This represents a marginal improvement over the 648.9 km total distance from the Nearest Neighbor (NNH) method.

The difference suggests that the SA is more adept at eliminating redundant travel segments and creating more concise routes.

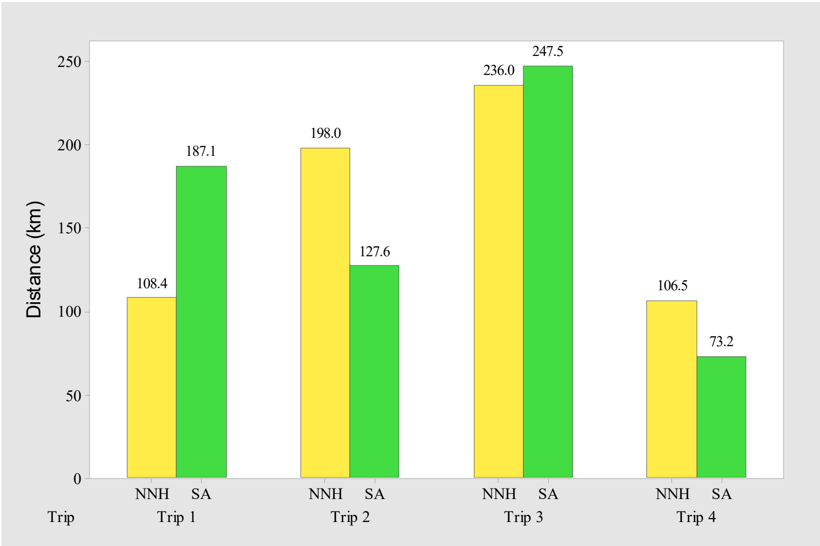

Figure 7 : Comparison of total distance per trip

To summarize, the analysis shows that the Saving Algorithm (SA) is more effective than the Nearest Neighbor Heuristic (NNH). It offers a better distribution of attractions, more value for time spent, and a reduction in overall travel distance (summarized in Table 5), without sacrificing coverage of all locations. Consequently, the SA stands out as a highly promising approach for real-world application in tourism route planning under time constraints.

The Saving Algorithm provides marginally better results in terms of overall distance and time savings, and it ensures a more balanced distribution of attractions across all routes. This is a notable advantage, even though the Nearest Neighbor Heuristic generates a single initial route with the highest number of locations.

Table 5: Comparative summary of NNH vs SA

List	Nearest Neighbor Heuristics (NNH)	Saving Algorithm (SA)	Observation
Total Number of Attractions	20 Attraction (4 routes)	20 Attraction (4 routes)	Equal
Total Time (minutes)	1,489	1,486	SA results in a slightly shorter total duration.
Total Distance (km)	648.9	635.4	SA is more efficient in terms of distance.
Route with Maximum Attraction	Route 1: 8	Route 2: 7	NNH generates a single route with the highest number of locations.
Balance Across Routes	Unbalanced (one route has only 1 Attraction)	More balanced	SA offers a more balanced distribution of locations.

3.5. *Discussion*

This research aimed to compare the effectiveness of two heuristic methods, the Nearest Neighbor Heuristic (NNH) and the Savings Algorithm (SA), for optimizing historical tourism routes in Songkhla Province. The results clearly indicate that the Savings Algorithm yields a superior solution compared to the Nearest Neighbor Heuristic in terms of overall efficiency and practical applicability. The discussion below interprets these findings, contextualizes them within the existing literature, and outlines their implications, limitations, and avenues for future research.

The primary finding of this study is the superior performance of the Savings Algorithm (SA), which generated routes with a shorter total travel distance (635.4 km vs. 648.9 km for NNH) and ensured a more balanced distribution of attractions across the four planned routes. While the NNH method is simpler in its greedy approach-always selecting the closest unvisited location-this very characteristic proves to be its main drawback. This myopic decision-making process can lead to suboptimal outcomes on a global scale, as evidenced by the creation of a highly inefficient final route containing only a single attraction. This route, despite its short duration, represents poor time and resource utilization for a tourist. In contrast, the SA algorithm is designed with a more global perspective. Instead of looking for the next nearest point, SA evaluates the potential savings that could arise from merging any two tourist attractions into the same route. Essentially, SA calculates the distance that can be reduced by traveling directly between two attractions instead of returning to the starting point after each visit. The algorithm always prioritizes the pair of connections that yields the highest savings first. This method allows SA to naturally form logical and proximate clusters of attractions (Lim *et al.* 2019; Clarke & Wright 1964). The result is a route that is not only shorter in total distance but also has a demonstrably more coherent and balanced structure, which is a highly desirable characteristic for practical tour planning. Therefore, this ability to take a global view and prioritize the most valuable connections is the key factor that makes the SA algorithm significantly more effective in routing than NNH.

These findings are consistent with established knowledge in the field of operations research regarding the Vehicle Routing Problem (VRP). The NNH is widely recognized as a simple, fast heuristic, but it is often outperformed by more sophisticated constructive heuristics like the Savings Algorithm (Wu *et al.* 2017; Sarawan & Khumla 2025). The work of Clarke and Wright established the SA as a foundational and effective method for VRP, and our study validates its applicability and superiority within the specific, un-studied context of historical tourism planning in Songkhla. This research, therefore, fills a critical knowledge gap identified in the introduction by demonstrating a practical and effective application of these methods to a real-world regional tourism scenario, moving beyond generic or purely urban tourism models (Lim *et al.* 2019; Rani *et al.* 2018; Mangini *et al.* 2021).

The practical implications of this study are significant. For tour operators and tourism planners in Songkhla, the Savings Algorithm provides a robust and systematic framework for designing tour packages that are more efficient, cost-effective, and enjoyable for tourists. By minimizing travel time and distance, operators can reduce transportation costs and potentially fit more attractions into an itinerary without overwhelming the tourist. More balanced itineraries, as produced by SA, lead to a better-paced and more satisfactory tourist experience. Furthermore, from a sustainable tourism perspective, efficient routing can help mitigate traffic congestion and the associated environmental footprint (Pitakaso *et al.* 2024), contributing to the long-term preservation of Songkhla's historical and cultural heritage, a goal aligned with community-centric tourism development (Rani *et al.* 2018).

Despite the promising results, this study has several limitations that open avenues for future research. First, the model operates on static data, assuming a constant average travel speed and not accounting for real-time variables such as traffic fluctuations, road closures, or time-of-day dynamics. Future work could integrate real-time traffic data from APIs to create more dynamic and adaptive routing solutions (Lim *et al.* 2019). Second, the model's primary constraint is time (Tmax), while other real-world factors such as tourist preferences (e.g., interest in museums vs. temples), budget constraints, entrance fees, and specific opening hours of attractions were not explicitly incorporated into the optimization process (Wu *et al.* 2017; Zheng *et al.* 2022; Göncü 2025). A more advanced model could incorporate a multi-objective function or allow for user-defined preferences to generate personalized itineraries (Lim *et al.* 2019; Pitakaso *et al.* 2024; Mangini *et al.* 2021). Finally, this study was limited to two classic heuristic methods. Future research could explore the performance of more advanced metaheuristic algorithms, such as Genetic Algorithms, Tabu Search, or Ant Colony Optimization, which may yield even more optimal solutions, albeit at the cost of increased computational complexity (Zheng *et al.* 2022; Göncü 2025).

4. Conclusion

This study was conducted to develop and evaluate an optimized routing model for historical tourism in Songkhla Province by comparing two prominent heuristic methods: the Nearest Neighbor Heuristic (NNH) and the Savings Algorithm (SA). The research concludes that while both methods can generate feasible tour routes under a given time constraint, the Savings Algorithm is demonstrably superior in terms of both efficiency and practical applicability. The solution provided by the SA resulted in a shorter overall travel distance and, more importantly, yielded a set of routes with a significantly more balanced distribution of attractions. This balanced workload makes the itineraries more practical for tour operators and more enjoyable for tourists, avoiding the inefficient outcome produced by the NNH's myopic, greedy approach.

The findings of this research fill a notable gap in the literature by successfully applying and validating these classic vehicle routing heuristics within the specific, under-studied context of historical tourism planning in a regional Thai province. The study provides a tangible and systematic framework that tourism stakeholders in Songkhla can use to enhance operational efficiency, reduce travel costs, and improve the overall quality of the visitor experience. Ultimately, this research underscores the value of applying operations research techniques to real-world tourism challenges and provides a strong foundation for future work aimed at developing more dynamic, personalized, and sustainable tourism management solutions.

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