**Implementation of sustainable approach on ASKQ in the navigation system.**

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*Abstract:* 86% of the population of Malaysia uses a motorcycle. However, the usage of motorcycles is unsustainable due to economic and environmental reasons. While there are several approaches to cut down the distance people drive through providing manual navigation service, it is sometimes inaccurate and does not recommend two or more different locations at the same time. This study evaluated three score function algorithms that can solve the problems while recommending the optimal POIs. The methods include score functions using the mid-points, finding each of the top-1 places, and calculating the area by Heron's formula. The study indicated the most sustainable method, Heron's formula. In addition, this potentially proposes algorithm approaches in a sustainable way and suggests using the skyline method and variously distributed data are applicable.

# Introduction

In 2022, 86% of Malaysians used motorcycles on a per capita basis [1]. There is not a significant difference in the rate in any of the other Southeast Asian countries. The usage of motorcycles in Southeast Asian nations, such as Malaysia, is an anti-sustainability trend, not only for economic reasons, such as the rise in oil prices but also for grave environmental problems resulting from massive CO2 emissions [2]. As a result, researchers have come up with several methods for cutting down on the overall distance people drive. In this study, the limitations of the current navigation system's recommendations for multiple keyword queries will be highlighted, and a solution will be proposed.

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Figure 1: The examples of the location and queries.

There have been several techniques through GPS systems that present the recommended place closest to the user's location. It suggests a place that is closest to the user's current location, such as a café or restaurant but does not recommend many places at once. Suppose a user desires to visit a restaurant and café with the shortest total distance. The user initiates a search for the nearest restaurant (or café), which the guidance system provides. The problem then comes when the user searches for the nearest café (or restaurant) based on the prior location. Is the returned list of POIs truly the optimum? It is uncertain whether the user will always receive the best and most cost-effective route from the services, given that the user's goal is to minimize the total distance of traveling the given number of POIs.

In Fig 1, the red dot indicates the user's starting location, the yellow dots show cafes, and the blue dots represent restaurants. The current GPS system yields café 4, res 8. Consider the following score function:

… (1)

Based on the (1), café 2 and res 2 becomes the outcome. As demonstrated in Example 1 below, a given score function can affect the optimal set of POIs. The purpose of this study is to offer an efficient score function with a high degree of correctness among those that are possible and reasonable, to minimize CO2 emissions and computing resources. Adopting the *Top-k query* method, which returns the k number of the highest-scoring elements depending on the given score function, is another contribution. As a result, the shortest k path will be offered for more flexible and satisfactory decision-making.

Example 1. Limitation of the previous approach.

| **Set** | **Previous Approach vs Novel approach using score function** | | |
| --- | --- | --- | --- |
| ***Previous Approach*** | ***f(x)*** | ***TD*** |
| A (café 4, res 8) | O (this is returned if the previous approach is used) | 4.72 | 6.77 |
| B (café 2, res 2) | X | 4.27 | 5.12 |

The preceding approach will locate the closest café, which is café 4 in Fig 1. It prompts the user to manually find the nearest restaurant from the café, restaurant 8. The fact that the total distance of combination A (café 4 and restaurant 8) is 6.77 demonstrates that the previous approach occasionally yields an error. ( However, the true shortest total distance from the current location to the café and restaurant is combination B (café 2 and restaurant 2) as the previous approach returns . This problem can be addressed by first locating each of the midpoints that exist between the café and the restaurant, then calculating the distance from the current location to each of the midpoints, and finally comparing it to the total distance.

# Methods

## Heuristic 1

1. By applying formula 1, Comparison of Returned Answer

| Trial | Previous Approach vs formula 1 using score function | | | |
| --- | --- | --- | --- | --- |
| PA | H1 | answer | result |
| 1 | [3, 5] | [3, 5] | [3, 5, 44.31] | both |
| 2 | [0, 9] | [0, 9] | [0, 9, 55.83] | both |
| 3 | [4, 5] | [4, 7] | [4, 5, 67.28] | PA |
| 4 | [0, 9] | [0, 9] | [1, 9, 67.06] | neither |
| 5 | [2, 9] | [4, 8] | [4, 6, 90.61] | neither |
| 6 | [1, 8] | [1, 9] | [1, 9, 61.27] | H1 |
| 7 | [4, 6] | [4, 7] | [4, 7, 38.12] | H1 |
| 8 | [4, 6] | [4, 7] | [4, 7, 26.02] | H1 |
| 9 | [1, 6] | [1, 6] | [1, 6, 48.11] | both |
| 10 | [4,7] | [4,6] | [4, 7, 86.25] | PA |

The accuracy of previous approach is 0.5% and the heauristic1 is 0.6%.

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Figure 2: The examples of the location and queries when the novel approach is not the answer.

A seen in Fig.2, the mid-point of 0th and 6th object is (36, 48.5) and the mid-point of 4th and 6th object is (7,67). Using the novel approach, the distance from the current to mid-point to the 0th and 6th object is 45.6, while the distance from the current to mid-point to the of 4th and 6th is 52.0. When the distance is far, but the mid-point is closer to the current place, it yields error result.

## Heuristic 2

This algorithm will return the top-1 closest POI1 and top-1 closest POI2 from the current location respectively as the answer.

, … (2)

1. By applying formula 2, Comparison of Returned Answer

| Trial | Previous Approach vs formula2 using score function | | | | |
| --- | --- | --- | --- | --- | --- |
| PA | H1 | H2 | Answer | result |
| 1 | (2, 9) | [2, 9, 29.97] | (2, 9) | [4, 9, 41.59] | X |
| 2 | (0,8) | [0, 8, 34.44] | (0, 8) | [4, 8, 58.62] | X |
| 3 | (9,1) | [1, 9, 20.55] | (1, 9) | [1, 9, 24.16] | All |
| 4 | (8,2) | [4, 8, 24.87] | (2, 8) | [2, 8, 73.88] | Except H1 |
| 5 | (1,7) | [1, 7, 23.20] | (1, 7) | [1, 7, 41.24] | All |
| 6 | (4,6) | [0, 6, 45.64] | (4, 6) | [4, 6, 58.18] | Except H1 |
| 7 | (4, 9) | [4, 9, 18.74] | (4, 9) | [2, 9, 38.75] | X |
| 8 | (5, 3) | [3, 5, 8.5] | (3,5) | [3, 5, 21.45] | All |
| 9 | (8,1) | [1, 8, 11.34] | (1, 8) | [2, 5, 35.55] | X |
| 10 | (4, 5) | [0, 7, 36.75] | (4, 7) | [4, 5, 61.69] | PA |

The accuracy of heuristic 2 is 0.3%, the accuracy of heuristic 1 is 0.5%, and the accuracy of previous approach is 0.6%. When the top-1 closest POI1 and top-1 POI2 are not close to each other but if there are any other POI that are close to any café (or restaurant), then the error causes.

## Heuristic 3, Heron’s Formula

The third heuristic approach finds the minimum area by using Heron’s formula and returns the two POIs. Heron’s formula is , where area of triangle is A, is semi perimeter, and are side lengths [3]. (3)

1. By applying formula 3, Comparison of Returned Answer

| Trial | Previous Approach vs formula3 using score function | | | | | |
| --- | --- | --- | --- | --- | --- | --- |
| PA | H1 | H2 | H3 | Answer | Result |
| 1 | (2, 9) | [2, 9, 29.97] | (2, 9) | [4, 9] | [4, 9, 41.59] | H3 |
| 2 | (0,8) | [0, 8, 34.44] | (0, 8) | [3, 8] | [4, 8, 58.62] | X |
| 3 | (9,1) | [1, 9, 20.55] | (1, 9) | [1, 9] | [1, 9, 24.16] | All |
| 4 | (8,2) | [4, 8, 24.87] | (2, 8) | [2, 8] | [2, 8, 73.88] | Except H1 |
| 5 | (1,7) | [1, 7, 23.20] | (1, 7) | [1, 7] | [1, 7, 41.24] | All |
| 6 | (4,6) | [0, 6, 45.64] | (4, 6) | [4, 6] | [4, 6, 58.18] | Except H1 |
| 7 | (4, 9) | [4, 9, 18.74] | (4, 9) | [2, 9] | [2, 9, 38.75] | H3 |
| 8 | (5, 3) | [3, 5, 8.5] | (3,5) | [3, 5] | [3, 5, 21.45] | All |
| 9 | (8,1) | [1, 8, 11.34] | (1, 8) | [1, 9] | [2, 5, 35.55] | X |
| 10 | (4, 5) | [0, 7, 36.75] | (4, 7) | [4, 5] | [4, 5, 61.69] | PA, H3 |

Table 3 shows that the accuracy of heuristic 3 is 0.8%, highest accuracy among three different approaches.

# Evaluation

**A: Chart, line chart

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**C:** Chart, line chart

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**E:** Chart, line chart

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Fig 3: Changes in time when the range and the number of POIs are changed **A**. change in time when getting total distance. **B**. change in time when previous approach is applied. **C**. change in time when H1 is applied. **D**. change in time when H2 is applied. **E.** change in time when H3 is applied

Fig. 3 shows the upward slope trend, meaning that the time increases. Fig.3D has the minimum time which means H2 which has the most insufficient accuracy took less time compared to other approaches. Fig. 3D doesn’t have a linear line, showing the flaw that it doesn’t provide a constant answer. Fig. 3E shows the maximum time change and has a continuous linear line, unlike other figures. This shows that the higher time, the more accurate and the best route is returned.

# Conclusion

Current techniques require the user to find the closest POIs manually. To decrease the distance by providing top-k optimal POIs based on augmented spatial keyword query, several algorithms were simulated in this research: using the mid-point, finding each top-1 PO1s, and using Heron’s formula. The first method showed higher accuracy than the previous approach but didn’t always provide the best answer. The second method finding each top-1 POI from the current location showed lowest accuracy and took a shorter time. The method using Heron’s formula showed the highest accuracy. In future work, using variously distributed data would provide more accurate analysis and results. Skyline, an effective multi-criteria decision-making operator, are applicable as POIs can have different attributes [4].

References

1. Erin Hale , “Will electric motorbike sales take off across Asia?, BBC, 2022
2. Koossalapeerom, Triluck, et al. "Comparative study of real-world driving cycles, energy consumption, and CO2 emissions of electric and gasoline motorcycles driving in a congested urban corridor." Sustainable cities and society 45 (2019): 619-627.
3. Nelsen, Roger B. "Heron's formula via proofs without words." The College Mathematics Journal 32.4 (2001): 290.
4. Borzsony, Stephan, Donald Kossmann, and Konrad Stocker. "The skyline operator." Proceedings 17th international conference on data engineering. IEEE, 2001.