Web-Based Geographic Decision Support System for Boarding House Recommendation Using SMART and A*

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ABSTRACT

Selecting a boarding house is an important need for incoming students, especially in urban areas that offer many housing alternatives. The large number of available options often creates difficulties in choosing accommodation that matches user preferences. This study aims to develop a WebGIS-based boarding house recommendation system in Lhokseumawe by integrating the SMART method with the A* algorithm, where the travel distance generated by the A* algorithm is incorporated directly into the SMART evaluation process. The SMART method was used to evaluate and rank boarding house alternatives based on the criteria of price, distance, room size, bathroom type, Wi-Fi, air conditioning, and bed availability, while the A* algorithm was employed to determine the shortest travel route. The system was evaluated through calculation validation by comparing the SMART scores generated by the system with manual calculations, as well as through a preliminary user evaluation. The results showed that the system produced recommendation scores consistent with manual calculations, and the user evaluation indicated that the recommended boarding houses matched user preferences in the evaluated scenarios.

I. INTRODUCTION

The increasing mobility of students pursuing higher education has significantly increased the demand for temporary accommodation, particularly boarding houses (kos), in university cities [1]. Universitas Malikussaleh, one of the major higher education institutions in Aceh Province, attracts students from various regions, resulting in the rapid growth of boarding house accommodations around the Bukit Indah Campus. These boarding houses offer diverse characteristics in terms of rental price, distance from campus, room size, bathroom type, and supporting facilities, providing students with numerous accommodation alternatives [2]. Consequently, selecting the most suitable boarding house has become a multi-criteria decision-making problem because prospective tenants must evaluate several factors simultaneously according to their individual preferences [3]. In practice, boarding house selection is still commonly conducted through direct surveys, recommendations from relatives, or information shared on social media, making the selection process time-consuming, subjective, and often inefficient [4].

Decision Support Systems have been widely developed to assist users in selecting the most appropriate alternative based on multiple evaluation criteria [5]. Among various Multi-Criteria Decision-Making (MCDM) methods, the Simple Multi-Attribute Rating Technique (SMART) has attracted considerable attention because it employs a straightforward weighting mechanism, simple utility calculations, and flexible preference modeling [6]. In addition, SMART allows each evaluation criterion to be weighted according to its relative importance, making it suitable for recommendation systems that involve multiple decision attributes [7]. Therefore, this study adopts the SMART method to evaluate boarding house alternatives based on rental price, travel distance, room size, facilities, and bathroom type.

Besides accommodation quality, accessibility is another important factor influencing students when selecting a boarding house [8]. To represent accessibility more realistically, this study employs the A* algorithm to calculate the optimal travel distance between Universitas Malikussaleh

Bukit Indah Campus and each boarding house based on the road network [9]. Unlike conventional distance measurements that rely solely on straight-line calculations, the A* algorithm determines travel distance according to the available road network, producing route information that better reflects actual travel conditions[10]. The calculated travel distance is then incorporated directly as the distance criterion in the SMART evaluation process, allowing accessibility to influence the recommendation ranking rather than functioning solely as navigation information.

Amalia et al. [11] developed a boarding house recommendation system using the SMART method to evaluate multiple criteria and generate recommendation rankings for prospective tenants. Similarly, Sugianto et al. [12] proposed a web-based boarding house recommendation system by combining the AHP and TOPSIS methods to rank boarding house alternatives according to user preferences. These studies demonstrate that MCDM methods are effective in supporting boarding house selection through systematic evaluation of multiple criteria. However, the recommendation process in previous studies primarily focuses on ranking boarding house alternatives, while accessibility based on the actual travel route has not been incorporated directly into the decision-making criteria [13]. Consequently, the influence of route accessibility on the recommendation results remains limited.

To address this limitation, this study proposes a Web-Based Geographic Decision Support System that integrates the SMART method with the A* algorithm. Unlike previous studies, which primarily utilize MCDM methods to rank boarding house alternatives, this study incorporates the optimal travel distance generated by the A* algorithm directly into the SMART evaluation process. Furthermore, the recommendation results are presented through a Web-Based Geographic Information System (GIS), enabling users to visualize boarding house locations together with the corresponding travel routes interactively [14]. This integration provides a more comprehensive decision support approach by combining multi-criteria evaluation, route accessibility, and spatial visualization within a single system, thereby assisting prospective tenants in selecting boarding houses more objectively and efficiently [15]. Therefore, this study aims to develop and evaluate a Web-Based Geographic Decision Support System that integrates the SMART method and the A* algorithm to provide boarding house recommendations by considering both user preferences and actual route accessibility.

II. Research Methodology

A. Data Collection

The study used 150 boarding houses located around Universitas Malikussaleh Bukit Indah Campus as the research dataset. The data were collected from Google Maps, including location coordinates, rental prices, and other publicly available information. For boarding houses with incomplete information, additional data regarding room facilities and accommodation attributes were obtained through direct communication with boarding house owners or tenants. The collected data were verified by confirming unavailable or incomplete information directly with the corresponding boarding house owners or tenants. After data collection, a requirement analysis was conducted to identify the functional requirements of the proposed system, including boarding house recommendation based on multiple criteria and route visualization through a web-based Geographic Information System (GIS).

B. A* Algorithm and GIS Implementation

A* algorithm was employed to determine the optimal travel route between Universitas Malikussaleh Bukit Indah Campus and each boarding house. In this study, the road network was represented as a graph, where intersections were treated as nodes and road segments as edges. The shortest route was determined using the A* evaluation function shown in equation (4):

$$f(n) = g(n) + h(n) \tag{4}$$

Where:

$f(n)$: total estimated cost (distance) required to travel from the start node to the destination node through node (n)

$g(n)$: actual cost incurred from the start node to node (n)

$h(n)$: estimated cost from node (n) to the goal node

The value of $g(n)$represents the cumulative travel cost from the starting node to the current node. To illustrate the computation of the actual travel cost, the distance between two connected nodes can be estimated using the Euclidean distance shown in equation (5). The cumulative value of $g(n)$is obtained by summing the travel cost of all traversed road segments.

$$d = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2} \tag{5}$$

Where:

d : distance

x_1 : latitude coordinate 1

x_2 : latitude coordinate 2

y_1 : longitude coordinate 1

y_2 : longitude coordinate 2

The heuristic function, $h(n)$, estimates the remaining travel cost from the current node to the destination, guiding the search process toward the optimal route. In the developed system, the implementation of the A* routing process was assisted by the Open Source Routing Machine (OSRM), which computes the optimal route based on the OpenStreetMap road network. The resulting travel distance was subsequently used as the distance criterion in the SMART evaluation process. Finally, the recommendation results and travel routes were presented through a web-based Geographic Information System (GIS), enabling users to visualize boarding house locations and the recommended routes interactively.

C. *SMART Method*

The SMART method evaluates boarding house alternatives using seven decision criteria: price, distance, room size, bathroom type, Wi-Fi availability, air conditioning (AC), and bed availability. These criteria were selected based on previous studies and were further confirmed through a questionnaire distributed to prospective boarding house tenants. Respondents were asked to rank each criterion according to its level of importance. Based on the ranking results, percentage weights were assigned to represent the relative importance of each criterion in the SMART evaluation process. The resulting weights represent the overall preferences of the respondents and were used as the reference weights in the recommendation process. The final criterion weights are presented in table 1.

TABLE I
CRITERIA WEIGHTS

No	Criteria	Attribute	Weight
1	Price	*Cost*	30 %
2	Distance	*Cost*	25 %
3	Room Size	*Benefit*	15 %
4	Wifi	*Benefit*	10 %
5	AC	*Benefit*	5%
6	Bed	*Benefit*	5%
7	Bathroom	*Benefit*	10%
	Total weight		**100%**

1. *Utility Value*

Since the decision criteria have different measurement scales, the SMART method employs a utility function to transform each criterion into a comparable scale ranging from 0 to 1. Cost criteria, including price and distance, are normalized so that lower values receive higher utility scores, while benefit criteria, including room size, bathroom type, Wi-Fi availability, air conditioning (AC), and bed availability, are normalized so that higher values receive higher utility scores. The utility values are calculated using equations (1) and (2).

$$Benefit = u(x) = 100\frac{x - \min(x)}{\max(x) - \min(x)} \tag{1}$$

$$Cost = u(x) = 100\frac{\max(x) - x}{\max(x) - \min(x)} \tag{2}$$

Where:
$u(x)$: utility value of alternative (a_i) on criterion (i)
x : value of criterion (i)
$\max(x)$: maximum criterion value
$\min(x)$: minimum criterion value

2. *Final Rangking Calculation*

After obtaining the utility value for each criterion, the final SMART score is calculated by multiplying each utility value by its corresponding criterion weight and summing the weighted values. Boarding house alternatives are then ranked according to their final SMART scores, where the highest score represents the most recommended alternative. The final SMART score is calculated using equation (3).

$$S_I = \sum_{j=1}^{m} w_j\, u_{j(a_i)} \tag{3}$$

Where:
S_I : total score of the (i)-th alternative
w_j : normalized weight of the (j)-th criterion
$u_{j(a_i)}$: utility value of the (j)-th criterion for the (i)-th alternative

III. RESULT AND DISCUSSION

A. *A* Route Calculation Results*

The A* algorithm was applied to determine the shortest route between Universitas Malikussaleh Bukit Indah Campus and each boarding house. To illustrate the route calculation process, one boarding house was selected as a calculation example. Due to space limitations, only one calculation example is presented, while the remaining alternatives were processed using the same procedure. The route consists of several connected segments. For each segment, the travel distance was calculated using Equation (5), and the cumulative travel cost, *g(n)*, was obtained by summing the distances of all traversed segments. The following calculation presents the route from Universitas Malikussaleh Bukit Indah Campus to Kos Bu Ani.

Segment A-B
Coordinates
A = (5.221500, 97.045800)
B = (5.220800, 97.046400)

$d = \sqrt{(5.220800 - 5.221500)^2 + (97.046400 - 97.045800)^2}$
$d = \sqrt{(-0.000700)^2 + (0.000600)^2}$
$d = \sqrt{0.00000049 + 0.00000036}$
$d = \sqrt{0.00000085}$
$d = 0.000922$

Segment B-C
Coordinates
B = (5.220800, 97.046400)
C = (5.220000, 97.047200)

$d = \sqrt{(5.220000 - 5.220800)^2 + (97.047200 - 97.046400)^2}$
$d = \sqrt{(-0.000800)^2 + (0.000800)^2}$
$d = \sqrt{0.00000064 + 0.00000064}$
$d = \sqrt{0.00000128}$
$d = 0.001131$

Segment C-D
Coordinates
C = (5.220000, 97.047200)
D = (5.219100, 97.048100)

$d = \sqrt{(5.219100 - 5.220000)^2 + (97.048100 - 97.047200)^2}$
$d = \sqrt{(-0.000900)^2 + (0.000900)^2}$
$d = \sqrt{0.00000081 + 0.00000081}$
$d = \sqrt{0.00000162}$
$d = 0.001273$

Segment D-E

Coordinates
D = (5.219100, 97.048100)
E = (5.216900, 97.049350)

$$d = \sqrt{(5.216900 - 5.219100)^2 + (97.049350 - 97.048100)^2}$$
$$d = \sqrt{(-0.002200)^2 + (0.001250)^2}$$
$$d = \sqrt{0.000004840000 + 0.000001562500}$$
$$d = \sqrt{0.000006402500}$$
$$d = 0.002530$$

The cumulative travel cost, $g(n)$, was obtained by summing the travel cost of all traversed segments. The resulting cumulative value is presented as follows.

Accumulated Travel Cost ($g(n)$)
$$g(n) = 0.000922 + 0.001131 + 0.001273 + 0.002530$$
$$g(n) = 0.005856$$

The cumulative value was then converted into kilometers using the approximation that one degree corresponds to approximately 111 km.

Travel Distance
$$\text{Distance} = 0.005856 \times 111$$
$$= 0.650016 \text{ km} \approx 0.65 \text{ km}$$

The calculated travel distance of approximately 0.65 km represents the shortest route between Universitas Malikussaleh Bukit Indah Campus and the selected boarding house. This distance was subsequently used as the distance criterion in the SMART evaluation process. Consequently, the recommendation process considers both route accessibility and boarding house attributes in determining the final ranking.

B. *SMART Method Calculation*

The travel distance obtained from the A* route calculation was combined with the remaining boarding house attributes to form the dataset used in the SMART evaluation process. table 2 presents the test data used as the input for the SMART method.

TABLE 2
TEST DATA

Kos	Price	Dist	Bed	Size	Bath	WIFI	AC
Ani	5000000	0.65	1	2	1	1	1
CBL	7500000	2.22	1	2	1	1	1
Faisal	7000000	2.68	1	2	0	1	1
Usman	7000000	0.84	1	2	1	1	0

The SMART method evaluates each boarding house alternative based on the seven decision criteria shown in Table 2. Before calculating the final preference score, the criterion weights were normalized as presented in table 3.

TABEL 3
NORMALIZED WEIGHTS

Criteria	Weight	Normalized Weight
Price	30	0.30
Distance	25	0.25
Room Size	15	0.15
Bathroom	10	0.10
WIFI	10	0.10
AC	5	0.05
Bed	5	0.05

After the criterion weights were normalized, the utility value of each criterion was calculated using equations (1) and (2). The normalized utility values were then multiplied by their corresponding normalized weights to obtain the final SMART score using equation (3). To illustrate the calculation procedure, one boarding house was selected as a calculation example, while the remaining alternatives were evaluated using the same procedure.

Calculation example Kos Bu Ani
Price (Cost)
$$100 \times \frac{7500000 - 5000000}{7500000 - 4000000} = 71.43$$
Distance (Cost)
$$100 \times \frac{10.5 - 0.65}{10.5 - 0.65} = 100$$
Room Size (Benefit)
$$100 \times \frac{2 - 1}{3 - 1} = 50$$
Bathroom Type (Benefit)
$$100 \times \frac{1 - 0}{1 - 0} = 100$$
Wi-Fi (Benefit)
$$100 \times \frac{1 - 0}{1 - 0} = 100$$
AC (Benefit)
$$100 \times \frac{1 - 0}{1 - 0} = 100$$
Bed (Benefit)
$$100 \times \frac{1 - 0}{1 - 0} = 100$$
Weighted Utility Value
Price: $71.43 \times 0.30 = 21.43$
Distance: $100 \times 0.25 = 25.00$
Room Size: $50 \times 0.15 = 7.50$
Bathroom Type: $100 \times 0.10 = 10.00$
Wi-Fi: $100 \times 0.10 = 10.00$
Air Conditioning: $100 \times 0.05 = 5.00$
Bed: $100 \times 0.05 = 5.00$
Final score SMART
$$SMART = \frac{21.43 + 25.00 + 7.50 + 10.00 + 5.00 + 5.00}{100}$$
$$= \frac{83.93}{100} = 0.8393$$

The same calculation procedure was applied to all remaining boarding house alternatives to obtain their respective SMART scores. The final SMART evaluation results and ranking of all alternatives are presented in table 4.

As shown in table 4, Kos Bu Ani achieved the highest SMART score of 0.8393 and was ranked first among all boarding house alternatives. This result was mainly influenced by its lower rental price and the shortest travel distance, which received the highest criterion weights. These findings indicate that the SMART method effectively ranks boarding house alternatives based on multiple decision criteria.

TABLE 4.
SMART EVALUATION RESULTS

Kos	SMART Score	Rank
Kos Bu Ani	0.8393	1
Kos bang Usman	0.6130	2
Kos CBL	0.5852	3
Kos Faisal	0.5163	4

C. *System Implementation*

System implementation is the stage where the designed system is developed into a web-based application. The developed system is capable of handling criteria input, generating boarding house recommendations using the SMART method, and determining routes using the A* algorithm. The system results are consistent with the manual calculations, indicating that the implemented methods perform accurately. n practical use, the developed system can assist prospective students in finding boarding houses that match their preferences while helping boarding house owners improve the visibility of their properties. The boarding house data can also be updated whenever changes occur, ensuring that the recommendation results remain relevant.

1. *Home Page*

The recommendation page displays boarding house information, including price, distance, room size, available facilities, and compatibility score. A "View Route" button is provided to display the route to the selected location on a digital map, helping users choose a boarding house that best suits their preferences and needs.

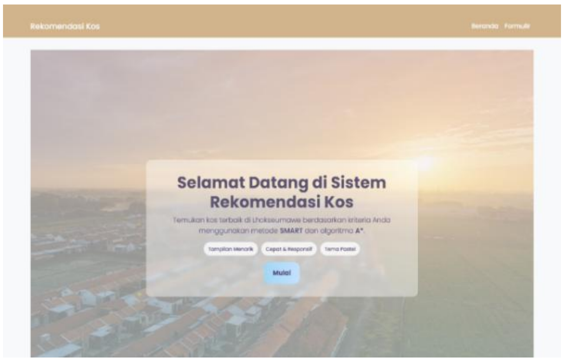

Figure 2. Home Page

2. *Form Page*

The form page allows users to input search criteria, including price, distance, room size, facilities, and bathroom type. An interactive map is provided to specify the user's starting location. The entered data are then processed using the SMART method and the A* algorithm to generate boarding house recommendations that match the user's preferences.

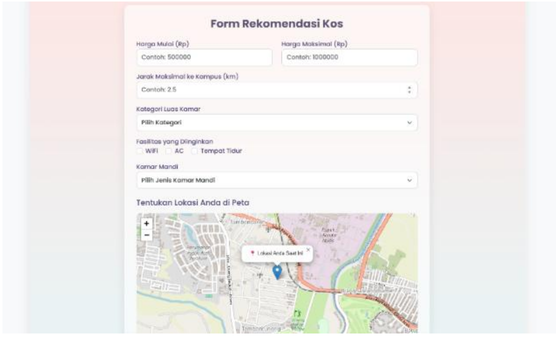

Figure 3. Form page

3. *Recommendation Page*

The recommendation page displays boarding house information, including price, distance, room size, available facilities, and compatibility scores. A "View Route" button is provided to display the route on a digital map, allowing users to compare available alternatives and select the most suitable boarding house.

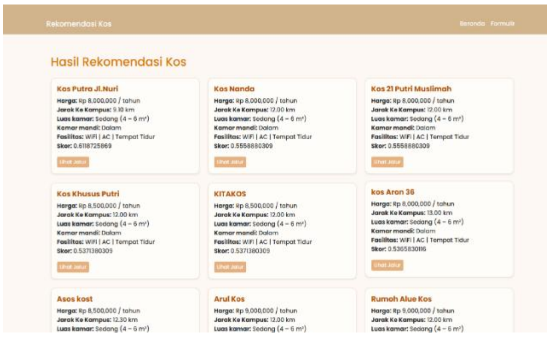

Figure 4. Recommendation Page

4. *Location Map Page*

The location map page displays information about the selected boarding house, including its price, distance from the user, and distance to the campus. An interactive map is provided to visualize the route to the destination using the A* algorithm, along with markers indicating nearby boarding houses. The system also displays the sequence of nodes traversed along the selected route.

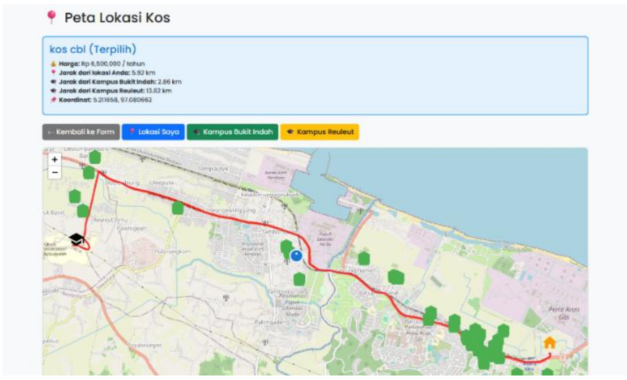

Figure 5. Location Map Page

D. *System Validation*

To evaluate the developed recommendation system, two validation approaches were conducted. First, a user evaluation was performed to determine whether the recommendation results matched user preferences. Second, the SMART scores generated by the system were compared with the corresponding manual calculation results to verify the correctness of the SMART implementation. The validation results are presented in tables 5 and 6.

TABLE 5.
USER EVALUATION RESULTS

Evaluation Item	Result
Participants	5 students
Recommendation matched user preferences	All participants
Overall user feedback	Positive

As summarized in table 5, all participants stated that the recommended boarding houses matched their preferences. These findings indicate that the developed system was able to provide recommendations consistent with user preferences in the evaluated scenarios

TABLE 6
CALCULATION VALIDATION RESULTS

NO	Kos	Manual Score	System Score	Difference	Validation status
1	Kos Buk Ani	0.8393	0.8393	0.0000	Valid
2	Kos Bang Usman	0.6130	0.6130	0.0000	Valid
3	Kos CBL	0.5852	0.5852	0.0000	Valid
4	Kos Faisal	0.5163	0.5163	0.0000	Valid

Table 6 shows that all SMART scores generated by the system are identical to the manual calculation results, resulting in a difference value of 0.0000 for all boarding house alternatives. This confirms that the SMART calculation was correctly implemented and consistently produced the expected recommendation scores.

IV. KESIMPULAN

Based on the research results, the developed WebGIS-based boarding house recommendation system was able to generate boarding house recommendations based on user-defined preferences and the selected decision criteria. The SMART method successfully evaluated and ranked the boarding house alternatives, while the A* algorithm determined the shortest travel routes and visualized them through the WebGIS interface. The preliminary user evaluation indicated that the recommendation results matched user preferences in the evaluated scenarios. However, further evaluation involving a larger number of users and broader evaluation scenarios is recommended to further validate the proposed system.

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