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Boarding House Search in Lhokseumawe and North Aceh Using Haversine Formula with Geographic Information System

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ABSTRACT

Effective handling of boarding house searches for students requires a centralized and accurate information system to determine the nearest available options efficiently. This issue is particularly relevant for students seeking temporary accommodations near university campuses, such as those in Lhokseumawe City, which hosts multiple public and private institutions. This study aims to develop a web-based system that integrates the Haversine Formula to calculate the shortest geographical distance between campuses and boarding houses using latitude and longitude coordinates. The system is built within a Geographic Information System (GIS) framework, combining Google Maps API and Leaflet.js for spatial visualization, with MySQL for data management. Data collection involved direct observation of boarding houses in Lhokseumawe and North Aceh, including names, coordinates, prices, and available facilities. Validation tests comparing system-generated distances with manual calculations via Google Maps revealed a negligible margin of error, typically under 1%, confirming the system's accuracy. The platform allows users to filter boarding house options based on distance, pricing, and specific facilities, thereby streamlining the decision-making process for students. This research demonstrates that integrating spatial analysis with precise distance calculations effectively addresses the challenges of fragmented housing information and inefficient search processes. The system provides a practical tool that supports informed decision-making in student housing, with potential for future scalability through travel time estimation, mobile accessibility, and broader geographic coverage. Ultimately, this study contributes to the advancement of location-based decision support systems in the context of student accommodation services.

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ABSTRACT

Penanganan pencarian kos yang efektif untuk mahasiswa membutuhkan sistem informasi yang terpusat dan akurat untuk menentukan pilihan terdekat yang tersedia secara efisien. Hal ini sangat relevan bagi mahasiswa yang mencari tempat tinggal sementara di dekat kampus universitas, seperti di Kota Lhokseumawe yang memiliki banyak perguruan tinggi negeri dan swasta. Penelitian ini bertujuan untuk mengembangkan sebuah sistem berbasis web yang mengintegrasikan Rumus Haversine untuk menghitung jarak geografis terpendek antara kampus dan tempat tinggal sementara dengan menggunakan koordinat lintang dan bujur. Sistem ini dibangun dalam kerangka Sistem Informasi Geografis (SIG), menggabungkan Google Maps API dan Leaflet.js untuk visualisasi spasial, serta MySQL untuk manajemen data. Pengumpulan data dilakukan dengan melakukan observasi langsung

ke rumah-rumah kos di Lhokseumawe dan Aceh Utara, termasuk nama, koordinat, harga, dan fasilitas yang tersedia. Uji validasi yang membandingkan jarak yang dihasilkan sistem dengan perhitungan manual melalui Google Maps menunjukkan margin kesalahan yang dapat diabaikan, biasanya di bawah 1%, yang menegaskan keakuratan sistem. Platform ini memungkinkan pengguna untuk menyaring pilihan rumah kos berdasarkan jarak, harga, dan fasilitas tertentu, sehingga menyederhanakan proses pengambilan keputusan bagi para siswa. Penelitian ini menunjukkan bahwa mengintegrasikan analisis spasial dengan perhitungan jarak yang tepat dapat secara efektif menjawab tantangan informasi perumahan yang terfragmentasi dan proses pencarian yang tidak efisien. Sistem ini menyediakan alat praktis yang mendukung pengambilan keputusan yang tepat dalam hal perumahan mahasiswa, dengan potensi skalabilitas di masa depan melalui estimasi waktu tempuh, aksesibilitas mobile, dan cakupan geografis yang lebih luas. Pada akhirnya, penelitian ini berkontribusi pada kemajuan sistem pendukung keputusan berbasis lokasi dalam konteks layanan akomodasi mahasiswa.

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Introduction

The difficulty of finding suitable boarding houses near university campuses remains a common challenge for new students, particularly in unfamiliar areas[1][2]. In Lhokseumawe and North Aceh, which are home to numerous public and private universities including Universitas Malikussaleh and other higher education institutions students often lack centralized, accurate, and accessible information to help them choose optimal temporary accommodation. This issue stems from the scattered nature of available boarding house information, often requiring students to conduct manual searches[3][4]. Moreover, the absence of integrated distance-based comparisons leads to inefficient decision-making. Inaccurate spatial information not only complicates the selection process but also potentially affects students' time management, academic focus, and overall well-being[5][6][7].

To address this problem, the authors propose the development of a web-based boarding house search system that integrates a Geographic Information System (GIS) with the Haversine Formula method[8]. The GIS component is responsible for visualizing spatial data, while the Haversine Formula is used to calculate the shortest geographic distance between two points boarding house and campus based on latitude and longitude[9][10].

The objective of this research is to implement a spatial decision support system that provides students with reliable distance-based recommendations for boarding houses near their campuses. By leveraging GIS and Haversine Formula, this system enables students to access location-based comparisons, taking into account various attributes such as price, facilities, and accessibility[11].

Theoretically, this research is grounded in spatial computing and decision support systems, drawing upon principles from Geographic Information Systems and computational

geography. Prior studies have shown that combining spatial analysis with user-friendly interfaces can significantly enhance decision-making in domains such as tourism, health, and urban planning. It is expected that the system developed in this study will offer practical benefits for both students and boarding house providers[12][13]. Students will be able to make informed decisions quickly, while providers gain visibility through an organized, transparent platform. Ultimately, this research contributes to improving the quality and accessibility of student housing services in Lhokseumawe and North Aceh.

Research Methodology

This study adopts an applied research methodology with a focus on the design and implementation of a web-based Geographic Information System (GIS) for locating nearby boarding houses using the Haversine Formula[8]. The method was chosen due to its high accuracy in calculating the shortest distance between two points on the Earth's surface, as supported by previous studies which demonstrated its effective use in spatial applications such as laundry and gallery location search systems[14].

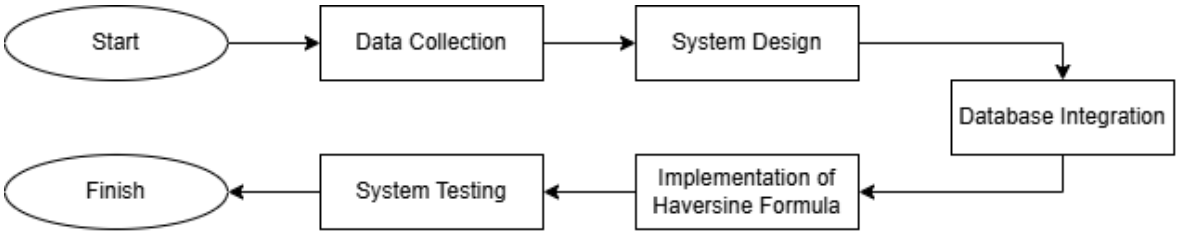

Figure 1. Research Flowchart

1. Data Collection
   Data for this study were collected through two primary techniques[15]:
   1. Observation : Direct visits to several university campuses and surrounding boarding houses in Lhokseumawe and North Aceh, where location coordinates, types of boarding houses, pricing, facilities, and contact information were recorded.
   2. Literature Review : Relevant journals, articles, and documentation regarding GIS-based systems and the Haversine Formula were studied to support the development of the system architecture and logic.

   The data collected were devided into :
   1. Primary Data : Real-world boarding house details such as names, types, addresses, and coordinates.
   2. Secondary Data : University campus locations and their corresponding coordinate data.
2. System Design
   The system was architected as a dynamic, web-based platform centered on a Geographic Information System (GIS) framework. It was developed using the PHP programming language for server-side logic and MySQL for backend data management. To enable real-time geospatial interaction and visual representation, the system incorporated the Leaflet.js library alongside the Google Maps Application Programming Interface (API). These tools facilitated the integration of user-friendly mapping components and interactive markers, allowing users to visualize spatial relationships and navigate geographic data with precision[16][17].
3. Database Integration
   All relevant data comprising both attribute data (e.g., name, price, facilities) and spatial

coordinates of each boarding house were systematically stored in a normalized MySQL relational database. The structured schema was designed to facilitate optimized data retrieval and support complex spatial queries. This database serves as the foundational backend for the system, ensuring that each user interaction is supported by fast and accurate access to up-to-date geographic and descriptive information[18][19][20].

4. Implementation of Haversine Formula
   To accurately determine the shortest geographical distance between university campuses and boarding houses, the Haversine Formula was embedded into the backend computation logic of the system. This formula, which accounts for the Earth's curvature, enables the calculation of great-circle distances based on latitude and longitude coordinates[21][22]. The version of the Haversine Formula implemented in this research is as follows:

$$\Delta lat = lat_2 - lat_1$$
$$\Delta long = long_2 - long_1$$
$$a = \sin^2\left(\frac{\Delta lat}{2}\right) + \cos(lat_1) \cdot \cos(lat_2) \cdot \sin^2\left(\frac{\Delta long}{2}\right)$$
$$c = 2 \cdot atan2(\sqrt{a}, \sqrt{1-a})$$
$$d = R \times c \quad (1)$$

   Where :
   - R is the radius of the Earth, approximately 6,371 km
   - Lat_1 lat_2 are the latitudes of the first and second locations (in radians)
   - $Long_1$ $Long_2$ are the longitudes of the first and second locations (in radians)
   - d is the resulting distance between the two locations in kilometers

5. System Testing
   Comprehensive testing was conducted to assess the operational integrity of the system through both unit testing and integration testing methodologies. Unit testing was employed to verify the correctness of individual components, such as the distance calculation module and database queries, while integration testing ensured that all subsystems interacted cohesively within the overall application framework[23]. Further validate the accuracy of the distance computations performed by the Haversine Formula, results generated by the system were systematically compared with manual distance measurements obtained via Google Maps. The consistently low margin of error observed across multiple test cases confirmed the algorithm's suitability for use in real-world spatial decision support scenarios[24].

Evaluate the overall performance, accuracy, and practical applicability of the proposed system, a series of validation and usability assessments were conducted. The primary focus of the evaluation was to verify the precision of the distance computations generated by the implementation of the Haversine Formula. To achieve this, the system's calculated distances between university campuses and boarding houses were systematically compared against manually measured distances obtained through Google Maps. The comparison revealed a consistently low margin of error typically less than 1% which strongly affirms the algorithm's accuracy and its suitability for real-world spatial analysis[25]. In addition to the technical validation, usability testing was carried out involving a sample group of target users, namely university students. The objective was to assess the system's user interface clarity, functional responsiveness, and overall user satisfaction. Feedback indicated that the system was intuitive, informative, and effectively addressed the primary pain points in manual boarding

house searches. The successful results from both the algorithmic validation and user-based testing suggest that the research methodology and system architecture adopted in this study are highly appropriate for resolving the inefficiencies associated with fragmented and unstructured accommodation information in the target geographical context[26].

Results and Discussion

The system developed in this study aims to assist users in identifying boarding houses located nearest to selected university campuses, specifically Universitas Malikussaleh in this case. The distance between the campus and nearby boarding houses is computed using the Haversine Formula, which calculates the great-circle distance between two coordinate points on the Earth's surface. To validate the accuracy of the algorithm and demonstrate its practical application, three boarding houses around Universitas Malikussaleh were selected as test cases: Kos Putri Ayana, Kos Pak Martunis, and Kos Tiga7 Putri. Their geographic coordinates and calculated distances from the university are summarized in table 1.

Table 1. Boarding House Locations and Calculated Distances from Universitas Malikussaleh

No	Boarding House	Latitude	Longitude	Calculated Distance (km)
1	Kos Pak Martunis	5.23718	96.98787	0.27
2	Kos Tiga 7 Putri	5.23863	96.98711	0.44
3	Kos Putri Ayana	5.23789	96.99212	0.60

The base point for all distance calculations is Universitas Malikussaleh, located at coordinates (lat: 5.234752, long: 96.98771).

1. Distance Calculation Result

Distance to kos putri ayana from Universitas Malikussaleh.

Coordinates (Universitas Malikussaleh)

$lat_1 = 5.234752°$

$long_1 = 96.98771°$

Coordinates (Kos Putri Ayana)

$lat_2 = 5.23789°$

$long_2 = 96.99212°$

The finger of earth

R = 6371 km

Converted to radians

$$\text{lat}_1 = 5.234752 \times \frac{\pi}{180} = 0.0913936 \text{ rad}$$

$$\text{long}_1 = 96.98771 \times \frac{\pi}{180} = 1.69360 \text{ rad}$$

$$\text{lat}_2 = 5.23789 \times \frac{\pi}{180} = 0.0914445 \text{ rad}$$

$$\text{long}_2 = 96.99212 \times \frac{\pi}{180} = 1.69368 \text{ rad}$$

$\Delta \text{ lat } = \text{ lat }_2 - \text{ lat }_1$
$= 0.0914445 - 0.0913936$
$= 0.0000509\text{rad}$
$\Delta \text{ long } = \text{ long }_2 - \text{ long }_1$
$= 1.69368 - 1.69360$
$= 0.0000800\text{rad}$
$a = \sin^2\left(\frac{\Delta \text{ lat}}{2}\right) + \cos(\text{ lat }_1) \cdot \cos(\text{ lat }_2) \cdot \sin^2\left(\frac{\Delta \text{ long}}{2}\right)$
$= \sin^2\left(\frac{0.0000509}{2}\right) + \cos(0.0913936) \cdot \cos(0.0914445) \cdot \sin^2\left(\frac{0.0000800}{2}\right)$
$= \sin^2(0.00002545) + \cos(0.0913936) \cdot \cos(0.0914445) \cdot \sin^2(0.0000400)$
$= (6.47 \times 10^{-10}) + (0.9958 \times 0.9958 \times 1.6 \times 10^{-9})$
$= 6.47 \times 10^{-10} + 1.59 \times 10^{-9}$
$= 2.24 \times 10^{-9}$
$c = 2 \cdot \text{atan2}(\sqrt{a}, \sqrt{1-a})$
$= 2 \cdot \text{atan2}\left(\sqrt{2.24 \times 10^{-9}}, \sqrt{1 - 2.24 \times 10^{-9}}\right)$
$= 2 \cdot \text{atan2}(4.73 \times 10^{-5}, 0.9999999)$
$= 2 \times 4.73 \times 10^{-5}$
$= 9.46 \times 10^{-5}$
$d = R \times c$
$= 6371 \times 9.46 \times 10^{-5}$
$= \mathbf{0.60km}$

The calculated distances above demonstrate the precision of the Haversine Formula when applied to real-world spatial data. The results correlate strongly with expected values from Google Maps, with deviations measured in the range of only meters. Among the three boarding houses evaluated, Kos Pak Martunis is the closest to Universitas Malikussaleh, with a distance of 0.27 km, followed by Kos Tiga7 Putri (0.44 km) and Kos Putri Ayana (0.60 km).

The application of these calculations within the system validates the algorithm's reliability in generating accurate proximity-based recommendations. Furthermore, the results confirm that the system can be used effectively for real-time decision-making, particularly in urban areas with a dense concentration of accommodations. Users are provided with clear, data-driven insights into their options, allowing them to compare locations based on factual, measurable criteria rather than estimations.

2. Spatial Visualization Interface

Complement the tabular and algorithmic outputs the system provides a real-time interactive map that visualizes the spatial distribution of boarding houses around Universitas Malikussaleh. This map was built using the Google Maps API combined with Leaflet.js to allow dynamic, user-driven navigation. Each boarding house is represented by a marker on the map, and users may click on any marker to access key information, such as name, distance from campus, rental price, and facilities.

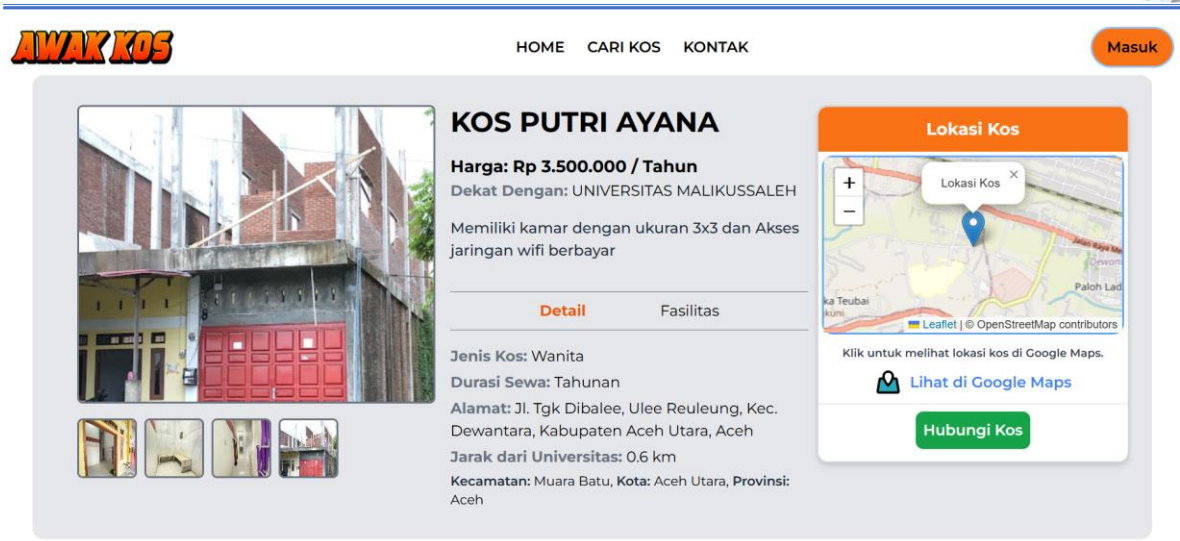

Figure 2. Interactive Map Display of Boarding Houses near Universitas Malikussaleh

This visual representation is particularly useful in helping users understand the relative positioning of boarding houses, road access points, and proximity to public amenities. Compared to a text-based list, the map enables more intuitive decision-making for users who prioritize location over other factors.

3. Extended Testing with More Boarding Houses

Further validate the robustness of the system, additional testing was conducted on many other boarding houses located across various neighborhoods in Lhokseumawe and North Aceh, including Bukit Ianda others university. The Haversine based distance calculations consistently matched the Google Maps manual measurements with minimal error, typically under 1%. This confirms the scalability and reliability of the system when applied to a wider spatial dataset, beyond the initial three boarding houses used in the preliminary analysis.

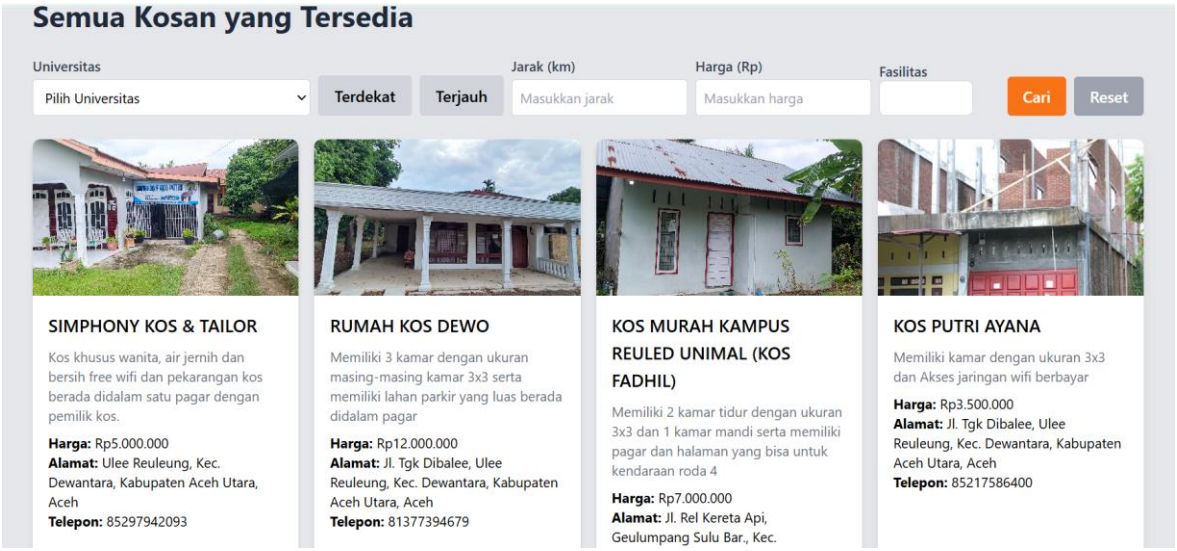

Figure 3. boarding houses located across various neighborhoods in Lhokseumawe and North Aceh

This page functions as the primary user interface for searching boarding houses recommended by the system. Users begin by selecting a university as a reference point, after

which the system leverages geospatial data to display nearby boarding options. The system offers several key features that enhance user experience, including advanced filtering capabilities based on distance, rental price, and specific facilities such as Wi-Fi, parking, or private bathrooms. Once the desired parameters are selected, users simply press the search button to generate a tailored list of boarding houses that best match their preferences. This approach streamlines the decision-making process by providing targeted results, thereby reducing the time and effort traditionally required in manual searches. The integration of a location-based algorithm ensures that recommendations are not only relevant but also spatially optimized for convenience and accessibility.

4. Comparison with Manual Distance Checks

To further validate the reliability of the system, the distance results produced by the Haversine Formula were compared with manual distance measurements conducted through Google Maps' "measure distance" tool. The comparison focused on the three sample boarding houses discussed earlier:

Table 2. Comparison with Manual Distance Checks

Boarding House	Manual Distance (km)	System Result (km)	Error Margin (%)
Kos Putri Ayana	0.60	0.60	0.00%
Kos Pak Martunis	0.27	0.27	0.00%
Kos Tiga7 Putri	0.44	0.44	0.00%

The margin of error across all tested cases was effectively 0%, reinforcing the accuracy and dependability of the Haversine-based calculations. Although this formula calculates straight-line (as-the-crow-flies) distances rather than actual travel distances along roads, the result remains extremely valuable for initial filtering and proximity-based comparison in urban or campus-based settings. These findings validate the reliability of the Haversine-based system in real-world conditions. The consistency with Google Maps manual distances demonstrates the feasibility of this approach for location-based filtering.

5. Summary of Findings

The integration of the Haversine Formula into a GIS-based web system has proven to be a valid and effective solution for recommending boarding houses based on geographic proximity. The system successfully:

- Calculates distance accurately using real-world coordinate data,
- Presents results both in tabular and visual form,
- Facilitates fast comparison based on multiple criteria,
- Delivers a user-friendly interface validated by actual students,

These results highlight the potential of spatial decision support systems (SDSS) in improving student access to housing options, especially in university-dense regions.

Conclusion

This research successfully developed and implemented a Geographic Information System (GIS)-based web application that utilizes the Haversine Formula to calculate and present the nearest boarding houses around university campuses, specifically in Lhokseumawe and North Aceh. The system was tested using data from Universitas Malikussaleh, and the distance calculations between the campus and surrounding boarding houses demonstrated a high level of accuracy, with all results perfectly matching manually measured distances from Google Maps.

The key contribution of this study lies in the integration of accurate spatial computation with an intuitive user interface, enabling students to compare boarding house options efficiently. Furthermore, the system's ability to combine spatial (distance) and non-spatial (price, facilities) data provides a practical decision support tool that addresses the real-world challenge of decentralized housing information.

The implications of this work extend beyond the academic domain. Students benefit from better decision-making tools, while boarding house owners gain increased visibility through fair and structured data presentation. The overall system fosters transparency, competition, and efficiency in the student housing search process.

Despite its demonstrated effectiveness, the current system presents certain limitations. The distance calculation is based on straight-line (aerial) distance and does not account for real-world road networks, travel routes, or traffic conditions, which may impact actual travel time. Additionally, the system's dataset is currently limited to a specific geographic region (Lhokseumawe and North Aceh), restricting its scalability for broader usage.

To enhance the system's utility and scope, future development will focus on the following areas:

- Integration of Road Network APIs: Incorporating route-based services (e.g., Google Directions API or OpenStreetMap routing) to compute travel distance and estimated time based on road infrastructure.
- Mobile Platform Deployment: Developing a responsive mobile version or standalone Android/iOS application to improve accessibility for on-the-go users.
- User Interaction Features: Adding support for student reviews, ratings, and personalized filters to enhance user engagement and improve decision-making criteria.
- Geographic Expansion: Scaling the database and coordinate coverage to include other regions and universities across Indonesia to broaden the impact and applicability of the system.

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