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Application of the haversine formula method to determine the closest distance to a minimarket

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ABSTRACT

In a digital era that demands speed and efficiency, determining the closest distance to minimarkets is crucial for consumers and the logistics industry. This study proposes the use of the haversine method to improve the accuracy of distance calculations. Through quantitative and quasiexperimental approaches, this study describes the steps of data collection, pre-processing, and application of haversine formulas. The results demonstrate the reliability of the haversine method in estimating distances accurately, allowing users to make more informed decisions in planning trips or logistics strategies. These findings contribute to the academic literature and field practice by providing a more robust and applicable methodology for determining the closest distance. Keywords: haversine, closest distance, minimarket.

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1. INTRODUCTION

In today's digital era, speed and efficiency in accessing information are very important, especially in determining the closest distance to a location, such as a minimarket (Hu et al., 2024). This is important not only for individuals but also for various industrial sectors that require route and delivery optimization (Singh et al., 2021). A frequent problem is inaccuracies in distance calculations that can result in inefficient allocation of time and resources. In rapid urbanization and traffic density, determining the fastest and closest route concerns not only time efficiency but also energy consumption and carbon emissions (Li et al., 2020). This study was conducted to address the problem of inaccuracies in the calculation of distances between individual locations and the nearest minimarket, which can have a significant impact on consumer decisions and business logistics (Pot et al., 2021).

This study aims to develop a more accurate method in determining the closest distance to minimarkets, using the haversine formula (Lerner et al., 2024)). This is important because it can help the general public, retail entrepreneurs, and other relevant stakeholders in planning trips or shipping goods more efficiently (Stone et al., 2022). The haversine method was chosen for its ability to calculate the shortest distance between two points on the earth's surface by considering the spherical shape of the earth (Baskar & Anthony Xavior, 2021). This research will fill the existing gap by offering a more accurate and reliable solution than traditional distance calculation methods that may not account for the curvature of the earth (Belda et al., 2020).

In this study, it will be explained how the haversine method can be applied in the context of determining the closest distance to minimarkets (Sudiatmika et al., 2021), including the state of the art of the method and proposed innovations. This research is expected to make a significant contribution in academic literature and field practice by presenting a more robust, accurate, and applicable methodology. This research is expected to not only produce innovative and effective

methodologies in calculating distances but also provide new insights in decision making related to route planning and logistics (Tian et al., 2023), (Yáñez-Sandivari et al., 2021). The results of this study are expected to provide useful recommendations for stakeholders in various sectors, especially in the retail and logistics industry.

The Haversine method calculates the distance between two points expressed in geographic coordinates (such as latitude and longitude) (Soe & Thein, 2020). This is due to the fact that the euclidean or manhattan vomit method is suitable for calculating distances in euclidean space, which is a flat representation of the world. However, the earth is a curved three-dimensional object, so the euclidean or Manhattan method will not provide an accurate estimate of the distance between two points on the earth's surface. Haversine's method, on the other hand, considers the curvature of the Earth's surface and uses spherical trigonometry to calculate the more accurate distance between two points in geographic coordinates (Faisal & Zamzami, 2020).

By understanding the distribution patterns of convenience stores and their distance from reference points, business owners can make better decisions in selecting new locations, evaluating potential expansion areas, and planning more effective marketing strategies (Hao et al., 2021). Minimarket owners can use this information to choose a strategic location by taking into account the relative distance from competitors, transportation accessibility, and local population density. Specific impacts expected include improved operational efficiency, increased revenue, and increased customer satisfaction due to better convenience store availability and better service.

Location search research was conducted previously regarding the search for the location of the nearest health facility using the haversine formula to find the nearest health facility based on the current user's location, with a test result of 82.38% that the application built is in the very good category(Hidayati & Mutiah, 2022), another study on the location gathering point in Bontang City using the haversine formula method, stated that this application is suitable for use and published to the public (Nugroho et al., 2020). Another study on the dance of the nearest hospital, in Semarang, had a formula with results can be used (Husada et al., 2020). Another study on the Determination of the Shortest Path for Climbing Mount Merapi on the Selo Path, using the Dijkstra Algorithm and the haversine formula, with the results obtaining a value in the "Good" category (Sumaryo et al., 2020). Another study on the admission of new participants in the zoning path uses the haversine formula, for the search for the location of the nearest school, Google Maps API presents programming functions to be integrated in the web or application that is being created. Meanwhile, information about school data is presented and integrated in the goegraphic application (Winoto et al., 2020). The integration of real-time data, such as traffic or weather conditions, has not been discussed in depth. The use of static data can reduce the accuracy of optimal location search results.

2. RESEARCH METHOD

This study used a quantitative approach with a quasiexperimental design to test the effectiveness of the Haversine method in determining the closest distance (Greenaway-McGrevy & Phillips, 2023). This study used a quasiexperimental design, in which there was no random grouping or formation of a strict control group (Cook et al., 2020)). This design was chosen because it allows researchers to observe the effects of interventions on natural conditions without extensive manipulation (Viglia & Dolnicar, 2020). In this context, the intervention is the application of the haversine formula for calculating distances.

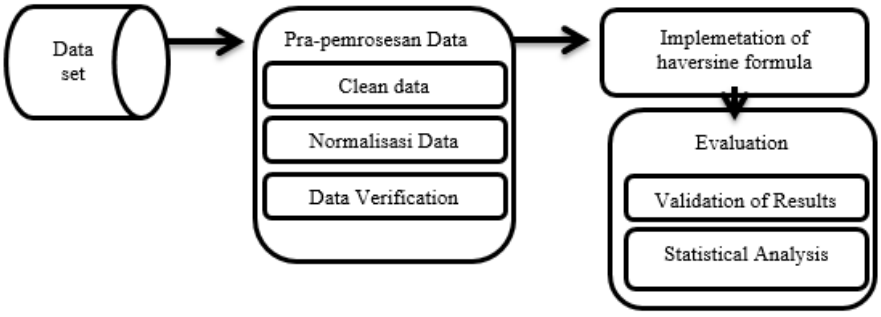

Figure 1. Research flow

Figure 1 illustrates the flow of the research process consisting of 3 main stages in the application of the haversine formula method to determine the closest distance. First, the process begins with 'Dataset', which then undergoes a series of 'data pre-processing' steps, the data preprocessing step is divided into three sub-steps: 'cleanup (Identifying and correcting or removing anomalies and errors of inconsistent data), 'Data normalization' (Converting latitude and longitude values to decimal format), and 'Data verification' (Ensuring all location data is in the correct format). After pre-processing, the prepared data is used for implementation for the 'haversine implementation formula' whereby the closest distance is sought. Finally, the results of the implementation of the haversine formula method are evaluated using 'statistical analysis' (to assess the significance of the results and ensure the method provides reliable distance estimation). All of these lines reflect a systematic research methodology to determine the closest distance to the market.

Data collection

Dataset ini mencakup koordinat geografis (latitude dan longitude) dari setiap toko serta data tambahan yang mungkin relevan untuk analisis. Pengumpulan data ini dilakukan melalui sumber yang tersedia secara publik atau kemitraan dengan entitas ritel.

Data Preprocessing

The pre-processing step involves data cleansing, including handling missing or inconsistent values, as well as normalizing coordinates. Clean data, identify and correct or remove data anomalies and errors such as missing, duplicate, or inconsistent entries (Hosseinzadeh et al., 2023). Data normalization, converting latitude and longitude values to a consistent decimal format for easy calculation (Bailer-Jones et al., 2021). Data verification, ensuring all location data is in the correct format. Avoid combining SI and CGS units, such as currents in amperes and magnetic fields in oersted. This often leads to confusion because the equations are not dimensionally balanced (Sun et al., 2022). If you must use mixed units, describe the units for each quantity you use in the equation.

Research procedure

The research will be carried out through four main stages, starting with the data extraction process, where the data will be imported from datatoko.xlsx files into the data analysis environment, using standard data import operations without requiring the use of mathematical formulas. The next step is data pre-processing, which includes cleaning the data from duplication, input errors, and incomplete or inappropriate data to ensure that the data is ready for analysis. application of the haversine formula to calculate the distance between reference points -6.922949, 109.130626 (Baptist et al., 2024). and every convenience store in the dataset. From this calculation, the study determined the nearest minimarket based on the shortest distance. Finally, pattern evaluation will be carried out by assessing the shortest distance found, focusing on measuring the effectiveness and accuracy of the Haversine method implemented in finding the closest distance to the mini market (Shami et al., 2024).

Analisa data

The analysis will focus on identifying the fastest or shortest path to the minimarket can influence buyer decisions, especially in store selection based on proximity or easy access from location (Tran & Sirieix, 2020). The haversine formula method works by calculating the shortest distance between two points on the earth's surface, considering the spherical shape of the earth (Yoon et al., 2024), using latitude and longitude coordinates. Data collection: first, collect data from publicly available sources or partnerships. The data must include a unique identifier for each record. Data processing, before applying the method, perform an initial process of data to ensure a consistent format (Lam et al., 2024). Includes ecoding distance items, handling missing values, and normalizing data if needed. Haversine method used to find the shortest distance between two points on a spherical surface based on latitude and longitude (El-Sayed et al., 2022). the main tool for calculating the distance between certain coordinate points, such as the location of customers or reference points, with the location of minimarkets (Formánek & Sokol, 2022).

Validate the results using the Haversine method formula, first, converting latitude and longitude coordinates from the degrees minutes seconds (DMS) format to decimal degrees (DD).

After that, you can use the Haversine formula to calculate the distance between the two points (Veena, 2022).

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$$\alpha = \sin^2(\frac{\Delta lat}{2}) + \cos(lat_1) \cdot \cos(lat_2) \cdot sin^2(\frac{\Delta long}{2})$$
$$c = 2.\text{atan}2\ (\sqrt{\alpha}, \sqrt{1-\alpha}) \quad (1)$$
$$d = R \cdot c$$

Where Δlat is the latitude difference between two points in radians, Δlong is the longitude difference between two points in radians, lat_1dan ⟦(lat⟧_2 is the latitude of the two points in radians, R is the radius of the Earth in units equal to the unit of length used (for example, kilometers or miles), α is the variable used in haversine calculations, c is the distance in units of Earth radius, and d is the distance between two points in units of length used. Statistical Analysis performs various statistical analyses to understand patterns or trends in data using descriptive statistical analysis, summarizing and describing the distribution of distances between points.

Evaluation

The evaluation involves an overall assessment of the effectiveness of the haversine method in the study, including its ability to provide useful and accurate information to determine the closest distance to the convenience store. Statistical analysis of calculation results using the haversine formula method (Ishak et al., 2021), including descriptive statistical calculations and other analyses to understand patterns and trends in data.

3. RESULTS AND DISCUSSIONS

The results of the discussion revealed several key findings. This study took a sample of location data that included the geographical coordinates of various minimarkets. The use of the haversine formula shows a significant ability in calculating the accurate distance between two geographical points, taking into account the curvature of the earth. The results of this calculation are compared with other distance calculation methods and actual data to test validity.

Table 1. Minimarket data

No.	Minimarket Name	Latitude point	Latitude point	Address
1	Indomart kalimati	-6.922.367	109.135.258	kajen,lemah duwur
2	Alfamart lemah duwur	-6.921.601	109.135.432	Lemah duwur
3	Indomart singkil	-6.930.068	109.128.035	kb. Baru, Adiwerna
4	Minimarket kita talang	-6.915.416	109.134.505	Wirantakan, Talang
5	Toserba	-6.926.259	109.130.272	Pesarean, Adiwerna
6	Java kita swalayan	-6.930.387	109.130.384	kb. Baru, Adiwerna
7	Alfamart talang	-6.913.722	109.134.287	Wirantakan, Talang
8	Indomart pesayangan	-6.919.453	109.142.840	Langgen, Talang
9	Indomart raya	-6.937.063	109.125.312	Kwaden, Ujungrusi
10	Indomart tegal wangi	-6.908.618	109.131.640	Pesendokan, Tegal wangi
11	Berkah putra minimarket	-6.905.874	109.144.695	Kaladawa, Talang
12	Indomart kaligayam	-6.904.197	109.135.910	Sutapranan, Dukuhturi
13	Indomart pagedangan	-6.941.936	109.122.207	Kaliwadas, pagedangan
14	Indomart pagongan	-6.902.265	109.134.068	Kenasan, Bandasari
⋮	⋮	⋮	⋮	⋮
50	Minimarket kita ujungrusi	-6.941.255	109.131.979	Pekalangan, Ujungrusi

Table 1 is a list of minimarkets along with their geographical coordinates and location addresses. There are various types of minimarkets with locations scattered in several areas, such as kajen, lemah duwur, kb. Baru, Adiwerna, Wirantakan, Talang, Langgen, Ujungrusi, Pesendokan, Tegal wangi, Kaladawa, Sutapranan, Dukuhturi, Kaliwadas, Pagedangan, Kenasan, Bandasari, and Pekalangan, Ujungrusi. This information provides important information for mapping the location of minimarkets and analyzing their geographical distribution, which can be used for route planning, density analysis, and strategic decision making related to the placement and management of minimarkets.

To use the Haversine formula to calculate the distance between the reference points in the data and each convenience store must first convert the latitude and longitude coordinates from degrees to radians. In order to be able to use the Haversine formula to calculate the distance between two points on the surface of the earth.

Table 2. Radian data

No.	Minimarket Name	Latitude point (radians)	Longitude point (radians)	Address
1	Indomart kalimati	-0.120818	1.904770	kajen,lemah duwur
2	Alfamart lemah duwur	-0.120805	1.904773	Lemah duwur
3	Indomart singkil	-0.120953	1.904644	kb. Baru, Adiwerna
4	Minimarket kita talang	-0.120697	1.904756	Wirantakan, Talang
5	Toserba	-0.120886	1.904683	Pesarean, Adiwerna
6	Java kita swalayan	-0.120958	1.904685	kb. Baru, Adiwerna
7	Alfamart talang	-0.120667	1.904753	Wirantakan, Talang
8	Indomart pesayangan	-0.120767	1.904902	Langgen, Talang
9	Indomart raya	-0.121075	1.904596	Kwaden, Ujungrusi
10	Indomart tegal wangi	-0.120578	1.904706	Pesendokan, Tegal wangi
11	Berkah putra minimarket	-0.120530	1.904934	Kaladawa, Talang
12	Indomart kaligayam	-0.120501	1.904781	Sutapranan, Dukuhturi
13	Indomart pagedangan	-0.121160	1.904542	Kaliwadas, Pagedangan
14	Indomart pagongan	-0.120467	1.904749	Kenasan, Bandasari
⋮	⋮	⋮	⋮	⋮
50	Minimarket kita ujungrusi	-0.121148	1.904712	Pekalangan, Ujungrusi

Table 2 contains the latitude and longitude coordinates (in radian format) of several convenience stores and their addresses. Coordinate analysis shows that these minimarkets are scattered in several different locations with very wide regional potential, there are several minimarkets whose coordinates are relatively close, such as: For example, Indomart Kalimati supermarket and Alfamart Lemah Duwur, Department Store, and Java We may indicate that these stores operate in the same area or adjacent to each other. However, the coordinates of several mini markets such as Indomart Padangan and Indomart Raya are quite far apart, indicating that the mini market network is more widespread. From these data, it can be concluded that these minimarkets cover very different areas, Maybe to meet people's shopping needs.

The application of the Haversine formula for determining the shortest distance from the reference point to the convenience store demonstrates the reliability of an accurate forecast. Through this analysis, the resulting distance data provides a comprehensive picture of the location of the convenience store relative to the reference point It is important to make travel decisions and plan shopping routes. This method takes into account the curvature of the ground surface to show how far the convenience store is from the reference point, thus giving users a more realistic and relevant picture.

Table 3. Evaluation results

No	Minimarket Name	Distance (km)
1	Indomart kalimati	0,52
2	Alfamart lemah duwur	0,55
3	Indomart singkil	0,85
4	Minimarket kita talang	0,94
5	Toserba	0,37
6	Java kita swalayan	0,83
7	Alfamart talang	1,10
8	Indomart pesayangan	1,40
9	Indomart raya	1,68
10	Indomart tegal wangi	1,60
11	Berkah putra minimarket	2,45
12	Indomart kaligayam	2,17
13	Indomart pagedangan	2,31
14	Indomart pagongan	2,33
⋮	⋮	⋮
50	Minimarket kita ujungrusi	2,04

Table 3 of the data is a list of minimarkets and their distance from a reference point, perhaps the city center or other location. Each convenience store has a sequence number, the name of the minimarket, and its distance from the center. The recorded distance varies from 0.37 km to 2.45 km. Department stores have the closest distance to the center which is 0.37 km, while Berkah putra minimarket has the farthest distance of 2.45 km. Data analysis shows that minimarkets that are located closer to the center tend to have shorter distances, while minimarkets that are farther away have longer distances as well. This may indicate a distribution pattern centered around a central point, with minimarkets that are moving further away from the center having reduced density.

By looking at the order of distance from the nearest to the farthest, it can be seen that Department Store, Indomart Kalimati, and Alfamart are the three closest minimarkets with a distance of under 1 km. While Berkah putra minimarket, Indomart kaligayam, and Indomart pagedangan are the three farthest minimarkets with a distance of more than 2 km. This information can be useful for convenience store business owners in evaluating their location, identifying potential areas for expansion, and planning marketing strategies and customer targeting. In addition, minimarket distance data can also be a consideration in transportation planning and accessibility for local residents.

In evaluating minimarket data and its distance from a reference point, there is a need to obtain up-to-date information on traffic and weather conditions. By integrating the Google Maps Traffic API for traffic information and the OpenWeatherMap API for weather information, convenience store business owners can gain a more holistic understanding of their surroundings. By leveraging the Google Maps Traffic API, business owners can get real-time updates on traffic conditions around the convenience store location. This information can help in planning freight routes or adjusting logistics strategies to minimize travel time and improve operational efficiency.

By using the OpenWeatherMap API, business owners can monitor the weather conditions around the location of the minimarket. Accurate weather information can help in anticipating potential disturbances such as rain or other bad weather that can affect the daily operations of the minimarket. By combining traffic and weather information from these two APIs, minimarket business owners can make better decisions in operational planning and marketing strategies. This data integration can also help in improving the customer experience by ensuring optimal product and service availability, as well as maintaining customer satisfaction in shopping at the minimarket.

Table 4. Real-time data integration

No	Minimarket Name	Traffic Cllondition	Weather Condition	Distance (km)	Estimated Travel Time (minute)
1	Indomart kalimati	Moderate Traffic	Clear	0,52	1.25
2	Alfamart lemah duwur	Heavy Traffic	Rainy	0,55	2.20
3	Indomart singkil	Light Traffic	Cloudy	0,85	1.28
4	Minimarket kita talang	Moderate Traffic	Clear	0,94	2.26
5	Toserba	Heavy Traffic	Clear	0,37	1.48
6	Java kita swalayan	Light Traffic	Rainy	0,83	1.25
7	Alfamart talang	Moderate Traffic	Clear	1,10	2.64
8	Indomart pesayangan	Heavy Traffic	Cloudy	1,40	5.60

No	Minimarket Name	Traffic Cllondition	Weather Condition	Distance (km)	Estimated Travel Time (minute)
9	Indomart raya	Light Traffic	Clear	1,68	2.52
10	Indomart tegal wangi	Moderate Traffic	Clear	1,60	3.84
11	Berkah putra minimarket	Heavy Traffic	Rainy	2,45	9.80
12	Indomart kaligayam	Light Traffic	Clear	2,17	3.26
13	Indomart pagedangan	Moderate Traffic	Cloudy	2,31	5.54
14	Indomart pagongan	Heavy Traffic	Rainy	2,33	9.32
⋮	⋮	⋮	⋮	⋮	⋮
50	Minimarket kita ujungrusi	Light Traffic	Clear	2,04	3.06

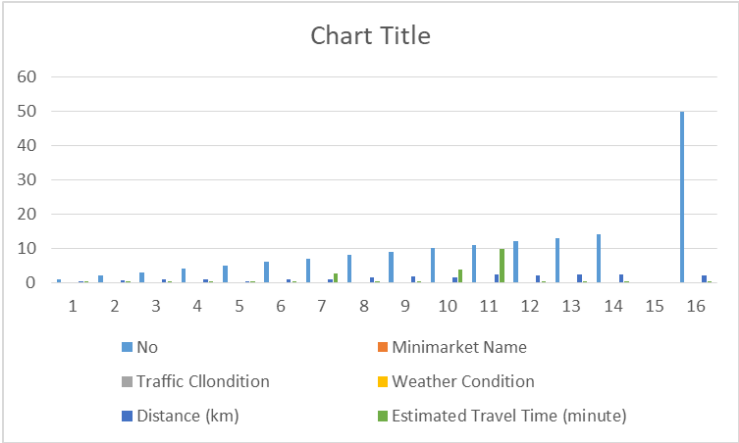

Figure 2. Graph

Table 4 of the data above, there are several factors that need to be considered to determine which minimarket to go to. One of the main factors is the distance traveled and the estimated travel time. From the data, the convenience store minimarket has a fairly short distance, only 0.37 km with an estimated travel time of 1.48 minutes. This shows that a convenience store can be an efficient option if your main goal is to reach the convenience store quickly. However, it should be noted that the Department Store is in heavy traffic conditions.

In addition, Indomart Kalimati is also interesting to consider because it has a fairly close distance, which is 0.52 km with an estimated travel time of 1.25 minutes. Although not as short as the convenience store, Indomart Kalimati is in moderate traffic conditions with sunny weather, which can affect the speed of travel. This can be a good option if you want to avoid heavy traffic.

In terms of which convenience store to go to, it depends on your personal preference. If your top priority is a short commute, a convenience store may be a better option despite being in heavy traffic conditions. However, if you prioritize lighter traffic conditions, Indomart Kalimati can be a good alternative. In essence, the final decision will be influenced by various factors such as time priorities, comfort, and personal preferences.

4. CONCLUSION

The use of the Haversine formula in determining the closest distance to a convenience store can provide accurate and useful information in travel decision-making and business strategy planning. By considering factors such as distance, traffic conditions, and weather, convenience store business owners can make better decisions in managing their daily operations and improving the customer experience.

The study only considers the physical distance between the convenience store and the reference point, without taking into account other factors such as the availability of goods, service quality, and consumer preferences. Further research can expand the scope to include these factors in the analysis, thus providing a more holistic picture of the selection of convenience stores.

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