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Frequency-Based Analysis of Mosque Qibla Errors in Medan

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Abstract

Mosque plays a vital role in supporting the performance of prayer comfortably and solemnly. However, one of the most crucial elements in mosque construction is the accuracy of the qibla direction facing the Kaaba. In cities far from the Kaaba, such as Medan, determining the qibla direction cannot be done visually and requires precise astronomical calculations and technical approaches. The problem that arises is the continued presence of mosques with qibla directions deviating from the correct orientation, which can affect the quality of worship for Muslims. This study uses a specially reduced mosque Qibla measurement sample data in Medan city. This paper analyzes data from 38 mosque samples with Qibla direction errors, which were re-measured by the UMSU OIF team. The data were then processed using a frequency distribution method to provide an overview of the error distribution in mosque Qibla directions across the city of Medan. This study found that the error often seen is a deviation of 9-12 degrees from the Qibla direction, and the mistake factors. This study also found that the misalignment of Qibla directions in Medan is mainly due to prioritizing land efficiency over directional accuracy during mosque construction, as well as relying on general assumptions and previously heard fatwas rather than precise astronomical calculations.

Keywords: qibla, mosque, Medan, frequency distribution

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Masjid memiliki peran penting dalam mendukung pelaksanaan ibadah salat secara khusyuk dan nyaman. Salah satu aspek krusial dalam pembangunan masjid adalah ketepatan arah kiblat menuju Kakbah. Di kota-kota yang jauh dari Mekkah, seperti Medan, penentuan arah kiblat tidak bisa dilakukan secara visual dan memerlukan perhitungan astronomis yang tepat. Namun, masih ditemukan masjid dengan arah kiblat yang menyimpang, yang dapat memengaruhi kualitas ibadah. Penelitian ini menganalisis data penyimpangan arah kiblat pada 38 masjid di Kota Medan, berdasarkan pengukuran ulang oleh tim OIF UMSU. Data tersebut kemudian diolah menggunakan metode distribusi frekuensi untuk melihat sebaran tingkat kesalahan arah kiblat. Studi ini menemukan arah kiblat di Kota Medan memiliki tingkat penyimpangan arah kiblat sebesar 9–12 derajat. Penelitian ini juga menemukan bahwa sebab kemelencengan arah kiblat di Kota Medan antara lain karena saat pembangunan masjid lebih mengutamakan efisiensi lahan daripada akurasi arah kiblat, serta penentuan kiblat didasarkan pada asumsi umum dan fatwa yang pernah didengar, bukan pada perhitungan astronomis yang tepat.

Kata Kunci: kiblat, masjid, Medan, distribusi frekuensi

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A. Introduction

Accurate determination of the Qibla direction is a crucial aspect of Islamic worship, particularly in performing the daily prayers. However, in recent years, misalignments in the Qibla direction have been observed in several mosques in the city of Medan. This issue is of significant concern, as deviations in the Qibla can affect the validity of prayers, especially for worshippers who are unaware of such discrepancies. During Qibla direction measurements conducted in various mosques throughout Medan, the Muhammadiyah University of North Sumatra's Astronomical Observatory (OIF UMSU) discovered that several mosques had inaccuracies in their Qibla alignment. These inaccuracies often result from the absence of proper Qibla determination during the construction phase, where the mosque's architectural design fails to align with the actual Qibla azimuth. This misalignment directly impacts the validity of prayers in these mosques, which depend on accurate orientation towards the Kaaba.

There are still many Muslims who face toward the qibla without understanding correctly whether the direction refers to the Kaaba or not. Facing the qibla (*Baitullāh*) in Islam is one of the requirements for the validity of one's prayer. For people who live in the city of Mecca, facing the Qibla is certainly not complex because they can witness the position of the Kaaba directly. However, it is different for Muslims who live far from Mecca and cannot see the direction of the Kaaba directly.[1]

Basically, facing the direction of the qibla when performing prayers, based on the command of Allah as follows:

قَدْ نَرٰى تَقَلُّبَ وَجْهِكَ فِى السَّمَاۤءِ فَلَنُوَلِّيَنَّكَ قِبْلَةً تَرْضٰىهَا ۪ فَوَلِّ وَجْهَكَ شَطْرَ الْمَسْجِدِ الْحَرَامِ ۗ وَحَيْثُ مَا كُنْتُمْ فَوَلُّوْا وُجُوْهَكُمْ شَطْرَهٗ ۗ وَاِنَّ الَّذِيْنَ اُوْتُوا الْكِتٰبَ لَيَعْلَمُوْنَ اَنَّهُ الْحَقُّ مِنْ رَّبِّهِمْ ۗ وَمَا اللّٰهُ بِغَافِلٍ عَمَّا يَعْمَلُوْنَ

> "Truly, We see that your face (Prophet Muhammad) often looks up to the sky. So, We will turn you to the qibla that you like. Then, face your face towards the Grand Mosque. Wherever you are, face your face in that direction. Indeed, those given the book know that (the transfer of the qibla to the Masjid al-Haram) is the truth of their Lord. Allah is not careless about what they are doing." (QS. Al-Baqarah: 144)

Before qibla moved to the Kaaba, the Prophet often raised his face towards the sky. The Prophet hoped that Allah would immediately move the qibla from Jerusalem to the Kaaba, so this verse came down. With this qibla movement, *Baitul Maqdis* in Jerusalem is no longer a legitimate prayer qibla. Jews and Christians know this very well. And indeed, those given the Torah and the Gospel know that the removal of the qibla is the truth of their Lord. They know this from their holy books. And Allah is not careless about what they are doing. Allah will undoubtedly record all the steps of those who go against His provisions.[2]

Most of the construction of places of worship, such as mosques, *muṣallā* (small mosque), or any designated spaces intended for Muslim prayer activities, is typically based on the orientation

[1] Hosen Hosen and Ghafiruddin Ghafiruddin, "Akurasi Arah Kiblat Masjid Di Wilayah Kecamatan Pademawu Kabupaten Pamekasan Dengan Metode Mizwala Qibla Finder," *AL-IHKAM: Jurnal Hukum & Pranata Sosial* 13, no. 2 (December 31, 2018): 364, https://doi.org/10.19105/al-ihkam.v13i2.1837.

[2] Muhammad Arsad Nasution, "Urgensi Sains Dalam Penerapan Petunjuk Al-Qur'an Dan Hadits (Analisis Terhdap Metode Penentuan Arah Kiblat, Hisab Rukyah Dan Waktu Shalat Dalam Ilmu Falak)," *Jurnal AL-MAQASID: Jurnal Ilmu Kesyariahan Dan Keperdataan* 7, no. 1 (December 11, 2021): 142–58, https://doi.org/10.24952/almaqasid.v7i1.4305.

and structure of the physical building itself. In other words, the direction that the building faces becomes the default Qibla direction for the worshippers who pray within it. As a result, wherever the mosque is oriented, Muslims inside it generally face that same direction during their prayers, assuming it is properly aligned toward the Qibla. Interestingly, in most cases, individuals who regularly perform their prayers in a mosque seldom question or verify whether the mosque's Qibla direction is accurately aligned with Mecca. This common attitude stems from a deep level of trust in the mosque's management or the original developers responsible for constructing the place of worship.[3]

Muslims in Indonesia have, from time to time, developed their own practical methods for determining the direction of the Qibla, especially in earlier periods when access to accurate tools or technology was limited. This approach was generally based on the information conveyed by religious scholars or ulama, who guided the community in religious matters. Initially, the information they received indicated that the direction of the Qibla from Indonesia was generally toward the West, since the Kaaba in Mecca, Saudi Arabia, is geographically located to the west of the Indonesian archipelago. This method was mostly done in a simple and approximate way, without involving precise calculations or detailed measurements, in order to make it easier and more accessible for Muslims to determine the Qibla direction for their prayers.[4]

Meanwhile, according to Butar-Butar, Shaykh Muhammad Arsyad al-Banjari is credited with pioneering the discourse on determining the direction of the Qibla in Indonesia. He was the first to address and update the Qibla direction in the country, particularly focusing on several mosques in Batavia (Jakarta). His efforts played a significant role in ensuring that the Qibla alignment in these mosques was more accurate, reflecting his deep concern for proper prayer practices among Muslims in the region.[5] Checking and measuring the direction of the Qibla in 1777 AD and getting a difference of 25 degrees to the right of the Jembatan Lima Mosque building with an explanatory note in Arabic.[6] This shows that the information on the direction of the Qibla that is still developing is that it is in the western direction of Indonesia.

Due to the geographical spread of Indonesia, the qibla azimuth direction varies from East to West across the country. Using spherical trigonometry, the azimuth for Indonesia ranges between 289.54° for locations in Eastern Indonesia and 301.05° for those in the western parts of the country. Eastern Indonesia: The Qibla azimuth is approximately 289.54°, reflecting the angle from regions, like Papua towards Mecca. This direction is slightly westward due to the easternmost position of these areas. Western Indonesia: In regions like Sumatra and parts of Java, the Qibla azimuth is 301.05°, indicating a more easterly alignment than the country's eastern provinces. This variation in

[3] Arwin Juli Rakhmadi Butar-Butar and Hasrian Rudi Setiawan, "Pengakurasian Arah Kiblat Di Lingkungan Cabang Muhammadiyah Medan Denai," *Al-Marshad: Jurnal Astronomi Islam Dan Ilmu-Ilmu Berkaitan* 4, no. 1 (June 30, 2018): 12–30, https://doi.org/10.30596/jam.v4i1.1932.

[4] Moch. Hadi Purwanto, "Penentuan Arah Kiblat Masjid Dengan Metode Bayang-Bayang Kiblat Studi Di Kecamatan Wonoayu Kabupaten Sidoarjo" (Universitas Islam Negeri Malang, 2013).

[5] Arwin Juli Rakhmadi Butar-Butar, *Kakbah Dan Problematika Arah Kiblat* (Yogyakarta: CV Arti Bumi Intaran, 2018).

[6] Arwin Juli Rakhmadi Butar-Butar, *Syaikh Muhammad Arsyad Al-Banjary (W. 1227H/1812M) Dan Arah Kiblat* (Medan: UMSU Press, 2021).

azimuth reflects the vast geographical diversity of Indonesia, making it necessary for each mosque or prayer space to accurately calculate the Qibla direction based on its specific location.[7]

Medan is one of the cities in North Sumatra, which is located at coordinates at 3° 30' – 3° 43' N and 98° 35' - 98° 44' E. For this reason, Medan's topography tends to slope north at 2.5 - 37.5 meters above sea level.[8] Institutions and units measuring the Qibla from this coordinate data can calculate its direction in Medan. The Observatorium Ilmu Falak (OIF) at Universitas Muhammadiyah Sumatera Utara (UMSU) holds a prominent role as one of Indonesia's leading astronomical institutions and is the first observatory established on the island of Sumatra. As a pioneering center for Islamic astronomy (*Ilmu Falak*), OIF UMSU is equipped with state-of-the-art astronomical tools and instruments, allowing it to engage in advanced scientific research. In addition to its research initiatives, the observatory actively serves the community by providing educational programs and resources related to astronomy. Through these efforts, OIF UMSU not only promotes the study of astronomy but also helps bridge scientific knowledge with Islamic practices, particularly in determining prayer times and Qibla direction.[9]

Among its community-oriented activities, OIF UMSU plays a crucial role in determining the direction of the Qibla for various religious and public establishments. It includes mosques, *muṣallā's*, open fields, offices, and other spaces for prayer. By 2019, the OIF UMSU team had measured. It estimated the Qibla direction for approximately 190 locations, extending their services not only within the city of Medan but also to regions outside North Sumatra Province.[10] The methodology employed by OIF UMSU in Qibla determination combines rigorous geodetic calculations and precise field measurements. The Qibla azimuth direction in Medan varied slightly, ranging between 292 and 293 degrees[11] depending on the specific geographical coordinates of the measurement site. This variance underscores the importance of meticulous calculation to ensure the accuracy of Qibla alignment, as even slight deviations can impact the fulfillment of Islamic prayer obligations.

These errors highlight the urgent need for public education on Islamic astronomy (*Ilmu Falak*) and the application of modern technology in qibla determination. Institutions like OIF UMSU are critical in addressing this issue through re-measurement programs, community outreach, and training for mosque administrators and the public. These efforts aim to ensure prayers follow Islamic guidelines while fostering greater awareness of the necessity for precision in determining the Qibla direction.

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[7] Sri Wahyuni, Muhammad Taufik Raisal, and Rafikatul Wardah Nasution, "Qibla Direction in Various Coordinates in Indonesia Using Spherical Trigonometry," *Al-Hisab: Journal of Islamic Astronomy* 1, no. 1 (2024): 15–23.

[8] Dhiauddin Tanjung, "Keragaman Penyimpangan Akurasi Arah Kiblat Masjid-Masjid Di Kota Medan (Tinjauan Latar Belakang, Upaya Akurasi Dan Solusi)" (UIN Sumatera Utara, 2016).

[9] Akrim Akrim, "Nilai-Nilai Pendidikan Islam Dalam Observatorium," *Al-Marshad: Jurnal Astronomi Islam Dan Ilmu-Ilmu Berkaitan* 6, no. 1 (June 1, 2020): 1–10, https://doi.org/10.30596/jam.v6i1.5224.

[10] Muhammad Qorib et al., "Peran Dan Kontribusi Oif Umsu Dalam Pengenalan Ilmu Falak Di Sumatera Utara," *Jurnal Pendidikan Islam* 10, no. 2 (November 30, 2019): 133–41, https://doi.org/10.22236/jpi.v10i2.3735.

[11] Dhiauddin Tanjung, *Ilmu Falak : Kajian Akurasi Arah Kiblat Kota Medan, Metode Dan Solusi* (Medan: Perdana Publishing, 2018), 1.

B. Method

This research is an analytical study of mosque qibla misdirection in Medan, employing the frequency distribution method to evaluate the extent and pattern of alignment deviations. The data analyzed in this study were obtained from qibla direction measurements of 42 mosques, recorded by the Observatorium Ilmu Falak Universitas Muhammadiyah Sumatera Utara (OIF UMSU) between 2015 and 2022. The measurement process was carried out using a theodolite, a high-precision instrument for angular measurements, following procedures that are primarily aligned with the standard practices of the Ministry of Religion in North Sumatra. In addition to field measurements, the results were verified using Google Earth satellite imagery, utilizing the bird's-eye view feature to visually assess the mosque's structural alignment with the true qibla azimuth.

Out of the 42 mosques measured, four were found to have accurate qibla directions or deviations within an acceptable margin (more than 0° but minimal). The remaining 38 mosques were identified as still misaligned with the correct qibla direction. The magnitude of the range (R) was calculated using Equation (1) to quantify the extent of these deviations. The range is critical for assessing the spread and severity of orientation errors across the sampled mosques. Through this approach, the frequency distribution of qibla misdirection can be visualized, and the analysis can offer insights into potential technical, environmental, or human factors contributing to these inaccuracies. The difference is the use of an additional software device called Google Earth, which shows a visual picture of the mosque measured through satellite images, "bird view" or the angle of view from the sky down (the surface of the Earth), and the image of the Mosque Qibla building is accurate or not.[12]

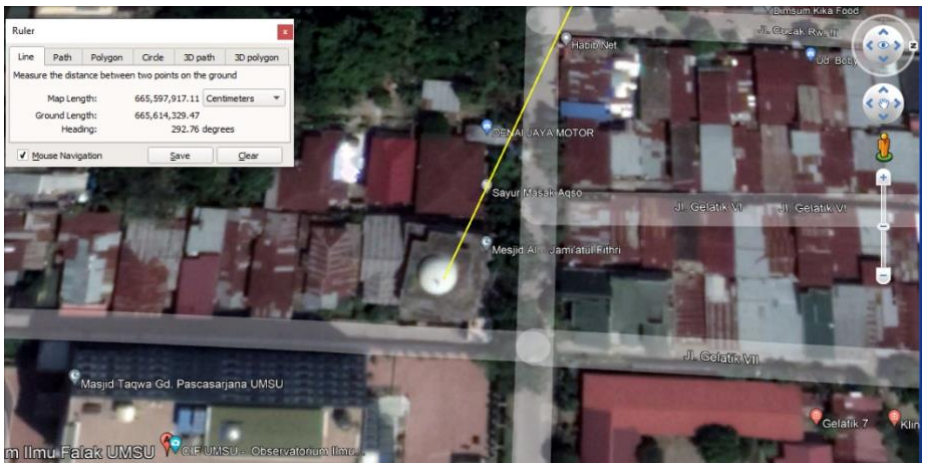

Figure 1. Mosque qibla direction display from Google Earth

The data used in this study on the Qibla direction was sourced from measurements taken at 42 mosques by OIF UMSU. Among these, four mosque points were found to have an accurate Qibla direction or a deviation of less than 0 degrees, indicating precise alignment. However, the remaining 38 mosques were identified as having Qibla directions that did not align correctly with the true Qibla.

[12] Hariyadi Putraga and Hasrian Rudi Setiawan, *Stellarium & Google Earth - Simulasi Arah Kiblat Dan Waktu Salat* (Medan: UMSU Press, 2018).

To analyze these findings, the data was processed and presented in the form of a statistical frequency distribution. This method was employed to illustrate how the frequency of variable occurrences – represented numerically– has been distributed, divided, or scattered across the mosques. The statistical approach allows for a clearer understanding of the accuracy of the Qibla directions in these mosques and the extent of any deviations.[13]

To quantify the extent of deviations in the Qibla direction of mosques in Medan City, the magnitude of the range (R) is calculated using Equation (1). This range is a critical metric that allows for an assessment of the distribution and severity of errors across the sample of mosques. By analyzing the range of errors, researchers can better understand the underlying factors contributing to inaccuracies in Qibla orientation.

The magnitude of R indicates how far the observed Qibla directions deviate from the true Qibla azimuth. A broader range reflects significant variation among the mosques, which may arise due to differing construction practices, geographic constraints, or inconsistencies in the methods and tools employed for Qibla determination. Understanding the factors responsible for these deviations is crucial for formulating targeted solutions, such as improved training for mosque planners, adopting standardized tools, or community education initiatives.

$$R = \text{Highest data} - \text{smallest data} \quad \ldots (1)$$

The data was then organized into class intervals to analyze the qibla direction errors in mosques in Medan comprehensively. For effective categorization, these intervals must satisfy several criteria: they should be equal lengths, continuous, and allow for the visualization of data diversity. This approach ensures a clear and systematic representation of error magnitudes across the sample. Equations (2) and (3) calculate the number of classes (k) and the length of each class interval (c). These equations provide the basis for constructing a frequency distribution table that accurately reflects the spread and concentration of Qibla errors.[14]

$$\text{Number of Classes } (K) = 1 + 3{,}3 \log n \quad \ldots (2)$$

where n is the total number of observations, determines the optimal number of classes based on the size of the dataset.

$$\text{Class Length } (P) = R / K \quad \ldots (3)$$

where R represents the range of the data and defines the length of each class interval, ensuring uniformity and continuity across the distribution.

This systematic organization of data enables a more accurate interpretation of error patterns and helps identify clusters of Qibla misalignments. By analyzing the frequency distribution, researchers can identify recurring degrees of deviation and investigate the underlying causes of these discrepancies. Such an approach not only highlights the extent of misalignment but also provides valuable insights into potential issues with mosque construction and alignment. Furthermore, this analysis supports the development of targeted interventions to correct Qibla

[13] Anas Sudjiono, *Pengantar Statistik Pendidikan* (Jakarta: Rajawali Pres, 2018).

[14] Tri Hidayati, Ita Handayani, and Ines Heldiani Ikasari, *Statistika Dasar* (Purwokerto: CV. Pena Persada, 2019).

determination inaccuracies, enhancing the overall accuracy of mosque orientations and ensuring proper alignment for future mosque constructions and renovations.

Subsequently, analyze the distribution of Qibla misalignments in the mosques of Medan through the use of graphs, charts, and comparisons of the mean, median, and mode of the Qibla direction. This method will provide a distinct visual representation of the data, facilitating the identification of trends and anomalies. Additionally, the research technique will be delineated to elucidate the approach employed in evaluating the precision of the Qibla direction in these mosques.

C. Result and Discussion

1. Distribution and Trends of Qibla Direction Deviations: A Case Study of Medan City

Slamet Hambali has defined the direction of the Qibla as a direction to the Kaaba that passes through the nearest distance. Muslims must face that direction when performing prayers, wherever they are. He further explained that the Qibla's direction is the closest to the Kaaba through the great circle of the Earth's sphere. The circle of the globe that passes by the direction of the Qibla can be called the Qibla circle, and the Qibla circle is defined as the circle of the Earth that passes through the axis or axis of the Qibla.[15] Meanwhile, Muhyiddin Khazin also determines the direction of the Qibla as the direction or the closest distance along the large circle that passes the Kaaba (Mecca) from the city where the person is located.[16] Astronomers define the direction in the sense of the direction to, or the closest distance from, a place to Mecca measured through a large circle, following modern theories such as Spherical Trigonometry and Geodesy, as well as Navigation theory, which defines the direction of travel or destination.[17]

After the invention of the magnetic compass, Muslims living far from Mecca relied on this tool to accurately determine the direction of the Qibla in their respective locations. Additionally, through two methods—flat plane measurement and spherical trigonometry—geodesic calculations became crucial in minimizing errors in Qibla direction determination. These methods allowed for precise measurements based on Earth's curvature, ensuring that even distant locations could align with Mecca. This advancement played a vital role in religious practices, improving the accuracy of Qibla orientation worldwide.[18]

In 2010, the Indonesian Ulama Council issued a fatwa related to the direction of the Qibla.[19] This *fatwa* still raises a problem today[20] because *fatwa* number 3 of 2010 states "The geographical location of Indonesia is in the eastern part of the Kaaba/Mecca, so the Qibla of Indonesian Muslims is facing the West." This fatwa was very helpful for the previous ummah to pray and build a mosque,

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[15] Muhamad Zainal Mawahib, "Metode Pengukuran Arah Kiblat Dengan Segitiga Siku-Siku Dari Bayangan Bulan" (UIN Walisongo Semarang, 2016), 57.

[16] Muhyidin Khazin, *Ilmu Falak Dalam Teori Dan Praktik* (Yogyakarta: Buana Pustaka, 2004).

[17] Ismail Ismail, "Arah Kiblat Dalam Perspektif Fikih Dan Geometri," *Mahkamah : Jurnal Kajian Hukum Islam* 7, no. 1 (April 27, 2022): 54, https://doi.org/10.24235/mahkamah.v7i1.10127.

[18] Ahmad Izzuddin, "Metode Penentuan Arah Kiblat Dan Akurasinya," in *(Annual International Conference on Islamic Studies)AISIS XII*, 2010, 759–60.

[19] HL Rahmatiah, "Pengaruh Human Eror Terhadap Akurasi Arah Kiblat Masjid Dan Kuburan Di Kabupaten Gowa Provinsi Sulawesi Selatan," *Elfalaky: Jurnal Ilmu Falak* 2, no. 1 (2020).

[20] Ahsin Dinal Mustafa, "Qibla Directions Through Ulama's Fatwa: Comparative Study between Qibla Direction Fatwa of Indonesian Ulama Council and Dar Al-Ifta Al-Misriyyah," *Al-Hilal: Journal of Islamic Astronomy* 1, no. 1 (October 1, 2019), https://doi.org/10.21580/al-hilal.2019.1.1.5675.

but it turned out to cause a mistake in the direction of the Qibla, which is about 22° to 26° from the actual direction of the Qibla. This fatwa has been revised to "Indonesia is not located in the east of the Kaaba but somewhat to the south, so the direction of the city's qibla is also not just west but slightly sloping, namely the northwest."[21]

The data collection to measure the direction of the Mosque Qibla was done by collecting and reducing data by focusing on re-measured mosques that found deviations or errors starting from the magnitude of the 1-degree error.

For the magnitude of the error range, the most minor data obtained is 1 degree. The most significant error difference is 27 degrees between the direction of the physical building of the mosque and the direction of the Mosque's Qibla, which is obtained using Equation (1) so that the magnitude of the range of error in the direction of the Qibla of the Mosque in the city of Medan is as follows:

$$R = 27° - 1° = 26°$$

From the magnitude of this range, if the direction of the Qibla of the Mosque in the city of Medan is, on average, 292° with an error range of 26°, the direction of the Qibla of the Mosque in Medan is still facing the West-Northwest, with the West direction being at an azimuth of 270°.

From equations (2) and (3), many classes and lengths of frequency distribution classes in the direction of the Qibla of mosques in Medan obtained as follows:

$$\text{Number of Classes } (K) = 1 + 3{,}3 \log 38$$
$$= 6{,}21328 \approx 7$$
$$\text{Class Length } (P) = R / K$$
$$= 26/7 = 3{,}714 \approx 4$$

Furthermore, the frequency distribution table of the statistical value of Qibla misdirection in Medan can be presented in the table below:

Table 1. Frequency Distribution Mosque Qibla error in Medan

Error	Relative Frequency (%)	Frequency (Mosque)
1-4 degree	15,78947	6
5-8 degree	15,78947	6
9-12 degree	18,42105	7
13-16 degree	15,78947	6
17-20 degree	15,78947	6
21-24 degree	7,894737	3
25-28 degree	10,52632	4
Total	100	38

[21] Komisi Fatwa MUI, "Fatwa Majelis Ulama Indonesia Tentang Kiblat" (2010).

Based on data above, we look for the Mean, Median, and Mode to see the degree of asymmetry or the symmetry distance of a distribution. To determine the mean magnitude of the frequency distribution, use the following Equation (4):

$$\bar{x} = \frac{\sum f_i . x_i}{\sum f_i} \ldots (4)$$

Then, using Equation (4), the magnitude of the Mean is obtained:

$$\bar{x} = \frac{\sum f_i . x_i}{\sum f_i} = \frac{499}{38} = 13{,}13158$$

Furthermore, to obtain the median size of the distribution data, the following grouped data median Equation is used:

$$Me = Lme + \frac{P(\frac{n}{2} - cf)}{fm} \ldots (5)$$

Then, using Equation (5), the Median is obtained:

$$Me = L_{Me} + \frac{\mathrm{K}(\frac{n}{2} - cf)}{fm} = 8{,}5 + \frac{4(\frac{38}{2} - 12)}{7} = 12{,}5$$

Furthermore, to obtain the magnitude of the mode of distribution data, the following median Equation of grouped data is used:

$$Mo = L_{mo} + K\left(\frac{d_1}{d_1 + d_1}\right) \ldots (5)$$

By Equation (5), the Median is obtained:

$$Mo = L_{mo} + K\left(\frac{d_1}{d_1 + d_1}\right) = 8{,}5 + \frac{7(7-6)}{(7-6)+(7-6)} = 12$$

The right-skewed distribution of the Qibla direction error data in Medan indicates that the majority of alignment errors among mosques fall within a relatively small range, predominantly below 12 degrees. This pattern suggests that most mosques in the city are generally aligned with the Qibla with acceptable accuracy. Only a smaller portion of mosques exhibits significant misalignment, exceeding 12 degrees. This distribution highlights a positive trend, as it shows that while a few mosques have notable errors, the overall alignment across Medan tends to be reasonably accurate, with most deviations remaining within a minor and correctable range.

Table 1 also presents the percentage distribution of Qibla direction errors among mosques in Medan. This data clearly illustrates that the highest concentration of errors lies within the 9–12-degree range, comprising 18% of the total sample. This suggests a notable proportion of mosques experience moderate misalignment in this category. Meanwhile, the error intervals of 1–4 degrees, 5–8 degrees, 13–16 degrees, and 17–20 degrees each account for 16% of the total, indicating a fairly even distribution of misalignment across these ranges. These values highlight a significant number of mosques with small to moderate deviations. In contrast, larger Qibla direction errors, specifically in the 21–24 degree and 25–28-degree ranges, contribute smaller proportions, at 8% and 10% respectively. This pattern suggests that while extreme misalignments do exist, they are less

common. Overall, the data points to a widespread but generally moderate level of directional inaccuracy.

2. Underlying Reasons for Inaccurate Qibla Alignment

Accurate Qibla alignment is an essential aspect of mosque construction, ensuring that acts of worship are correctly oriented toward the Kaaba. In Medan, however, statistical analysis has revealed a notable number of mosques with varying degrees of Qibla misalignment. Exploring the underlying reasons behind these inaccuracies is important for identifying gaps in practice and offering solutions for better future implementation. One of the key contributing factors in Medan is the construction process itself, which often prioritizes land availability and spatial orientation over scientific accuracy. Many mosques are built to align with existing property boundaries or urban layouts, rather than being guided by precise geodetic or astronomical calculations. In addition, traditional and outdated methods—such as using simple compasses or visual estimations—are still commonly used to determine Qibla direction.

The use of non-standard measuring tools and the lack of skilled personnel in Qibla determination contribute significantly to alignment inaccuracies. Additionally, limited public awareness regarding the importance of precise Qibla orientation and unfamiliarity with modern tools exacerbate the problem. These issues reflect a broader need for educational initiatives and technical outreach to improve understanding and practices. The findings underscore that inaccuracies in Qibla alignment in Medan are not solely due to technical shortcomings but also rooted in social and educational factors, highlighting the need for a comprehensive approach that addresses both domains to ensure better accuracy in the future.

The analysis revealed significant deviations in the Qibla direction of mosques in Medan, with most errors falling within a specific range. This distribution reflects standard practices and challenges in Qibla determination during mosque construction. The combined use of statistical analysis and graphical representation provided a holistic understanding of the issue, paving the way for targeted recommendations to improve Qibla accuracy in future mosque projects. The measurement data of the direction of the mosque, the total measurement of the mosque that has been measured in the city of Medan alone by the OIF UMSU team, the mosque condition that is used as a guideline for the direction of the Qibla of Muslims in the city of Medan, especially those used as the Object of this research, more than 50% of the direction of the Qibla deviates from 1° to 16°. Deviations greater than 16 degrees are to be less frequent.

According to an interview with Mr. Arman, a member of the Al-Muhajirin Mosque congregation in Medan Johor, several factors contributed to the Qibla misalignment. During the mosque's construction, the main priority was to make the most of the available land, with less emphasis on achieving precise alignment with the Qibla. As a result, the mosque was oriented westward, which was assumed to be correct based on a fatwa he had previously encountered. This indicates a dependence on general assumptions or traditional understanding rather than precise astronomical methods in determining the Qibla direction.

Furthermore, according to community leaders in suburban areas, the construction of smaller prayer halls (*muṣallā*) often relied on rough estimations. In many cases, the sunset direction is used as the Qibla direction reference based on the information available to them at the time. It indicates a lack of precise measurement tools or expertise in Qibla determination, leading to potential

deviations from the correct direction. Additionally, miscalculations in Qibla direction determining also stemmed from the non-standard tools or improper procedures. For instance, some individuals used compasses without following the correct methods, which could result in misalignment. The lack of awareness regarding using such instruments further contributed to these inaccuracies.

These findings highlight the critical need to raise awareness and educate the public about accurately determining the Qibla, particularly through the use of standardized measurement tools and proper astronomical methods. Misalignment of the Qibla often results from construction practices that neglect these tools or fail to account for precise geographic and astronomical factors. To ensure proper alignment, it is essential to incorporate scientifically accurate techniques in building design, fostering a deeper understanding of Qibla determination within local communities. Based on the interview, the key contributing factors are summarized as follows:

a. Mosque Construction Adjustment to Available Land

One of the most common reasons for Qibla misdirection was the physical alignment of mosque buildings to the available land.[22] In this study, the mosque structures are built to maximize the building's size by aligning it with surrounding infrastructure, particularly roads, rather than aligning it precisely with the Qibla direction. This adjustment to the land layout often resulted in deviations from the true Qibla azimuth. The focus on optimizing the mosque's spatial layout took precedence over ensuring precise alignment with the Kaaba, thus leading to errors in the Qibla direction.

b. Reliance on Approximate Methods for Determining Qibla

Another factor contributing to the misdirection was the reliance on estimates and approximations to determine the Qibla direction. Historically, some mosque builders based their calculations on the direction of the sun, particularly the sunset in the West.[23] As a rough guide to the Qibla. This method is inherently imprecise, as it does not account for the actual geographical position of Mecca and its correct azimuth from Medan. Additionally, these inaccuracies contributed to the lack of widespread knowledge regarding the scientific methods for determining the Qibla, such as celestial navigation or geodetic calculations. Many mosque constructors did not fully understand the importance of precise Qibla alignment, focusing instead on building the structure in a manner they believed was suitable.

c. Non-Standard Measuring Instruments

The third factor identified was using non-standard measuring tools during the Qibla determination process. Most of the mosques in Medan used basic magnetic compasses to estimate the Qibla direction. [24] The interviewees highlighted several key factors that contribute to the misalignment of the Qibla direction in mosques in Medan. These include

[22] Anisah Budiwati, Muhammad Wahyu Firdaus, and Galih Cipto Raharjo, "Integration Method For Measuring Qibla Direction (Comparative Analysis Of Google Earth And Mizwala)," *Indonesian Journal of Interdisciplinary Islamic Studies*, December 29, 2022, 147–64, https://doi.org/10.20885/ijiis.vol.5.iss3.art2.

[23] Suriah Pebriyani Jasmin et al., "The Accuracy Of Qibla Direction Of Cemeteries Using Modern Qibla Tools," *Jurnal Al-Dustur* 6, no. 2 (December 2, 2023): 157–75, https://doi.org/10.30863/aldustur.v6i2.4800.

[24] Muhammad Ikbal, "The Ideological Transformation Of Jam'iyah Rifa'iyah In Determining The Qibla Direction In Adinuso Batang Village," *Al-Hilal: Journal of Islamic Astronomy* 4, no. 1 (April 29, 2022): 99–114, https://doi.org/10.21580/al-hilal.2022.4.1.8336.

the practice of adjusting mosque construction based on available land, reliance on approximate methods to determine the Qibla, and the use of non-standard measuring instruments. Such practices result in significant deviations from the correct Qibla direction, affecting the accuracy of prayer orientation for mosque congregations. It is therefore essential for mosque committees and construction teams to be educated on modern, scientifically accurate Qibla determination methods to ensure proper alignment of mosque structures.

To address these issues, future efforts must prioritize standardizing the Qibla measurement process. This would involve ensuring the consistent use of precise geodetic and astronomical instruments for accurate determination of the Qibla direction. Additionally, fostering a broader understanding of the available technical methods among mosque committees, architects, and construction teams is critical. By integrating modern tools and techniques into mosque construction practices, it is possible to achieve precise alignment, ensuring that the Qibla is correctly oriented for the benefit of worshippers.

D. Conclusion

This research has revealed significant previously unknown findings regarding the orientation accuracy of mosques in Medan City. The study found that more than half of the surveyed mosques were misaligned from the proper Qibla direction, with deviations commonly ranging between 9 to 12 degrees and the most severe deviation recorded at 27 degrees. These misalignments raise serious concerns about the validity of prayers in these mosques — an issue that was not widely acknowledged before this research. The analysis identified several contributing factors, including the prioritization of land use over orientation accuracy during construction, reliance on rough estimations of the sun's position, and the improper use of measuring tools due to unsuitable equipment or lack of adherence to proper standards. These findings highlight the need for stronger awareness and education regarding Qibla determination, especially among mosque committees, architects, and construction teams. Institutions such as the Observatorium Ilmu Falak Universitas Muhammadiyah Sumatera Utara (OIF UMSU) are essential in providing technical assistance to ensure precise geodetic and astronomical methods for Qibla alignment.

Despite the significance of these findings, this research is not without limitations. The study was geographically limited to the Medan City area and primarily focused on the technical orientation of mosques without deeply exploring the historical, cultural, or social factors influencing construction decisions. Future research could address these aspects by expanding the study area, investigating community perceptions of Qibla alignment, and evaluating the effectiveness of educational outreach in promoting correct practices. Such studies would help rectify misaligned mosque orientations and offer a more holistic understanding of the relationship between religious practice, construction tradition, and scientific accuracy in the context of mosque design.

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