# COMPARISON OF SPHERICAL TRIGONOMETRY METHOD, JEAN MEEUS ALGORITHM AND GOOGLE QIBLA FINDER IN DETERMINING OF THE QIBLA DIRECTION OF ISLAMIC HOSPITAL

Firda Yunita Sari,[1*] Achmad Fachril Yusuf Ababil,[1] Urwatun Nafis,[1] Nita Ardelia,[1] Rofina Muti'atun Khasanah,[1] Nurissaidah Ulinnuha,[1] Abdulloh Hamid[1]
[1]Universitas Islam Negeri Sunan Ampel Surabaya – Indonesia
*Corresponding author. Email: firdasari465@gmail.com

**Abstract:**

Accuracy in facing the Qibla is an essential part of performing prayers. This vital value is evident when many mosques are built in public places. This article is qualitative with field data sources, namely coordinate points at the Jemursari Islamic Hospital mosque, Surabaya Islamic Hospital, and Al-Irsyad Hospital Surabaya. Once collected, the data was analyzed using three methods for calculating Qibla direction, namely Spherical Trigonometry, Jean Meeus, and Google Qibla Finder. This article found that the three methods obtained the same results at the Jemursari Islamic Hospital at 294°3'5", at the Surabaya Islamic Hospital at 294° 3'6", and at the Al-Irsyad Surabaya Hospital at 294°3'5 ". However, there is a difference between calculations and field measurements of 2°–7°, including within the Qibla deviation tolerance. It can be concluded that these three methods can accurately determine the Qibla direction in various locations. However, re-checking is required if the measurements exceed the tolerance limits.

***Keywords:*** *Accuracy; Qibla; Spherical trigonometry; Jean Meeus; Qibla Finder Google*

**Abstrak**

Keakuratan menghadap Kiblat menjadi bagian penting dalam pelaksanaan salat. Nilai penting tersebut tampak nyata ketika banyak masjid didirikan di tempat-

tempat umum. Artikel ini bersifat kualitatif dengan sumber data lapangan, yaitu titik koordinat di masjid Rumah Sakit Islam Jemursari, Rumah Sakit Islam Surabaya, dan Rumah Sakit Al-Irsyad Surabaya. Setelah terkumpul, data tersebut dianalisis menggunakan tiga metode penghitungan arah kiblat, yaitu Spherical Trigonometri, Jean Meeus, dan Google Qibla Finder. Artikel ini menemukan bahwa ketiga metode tersebut memperoleh hasil yang sama, di Rumah Sakit Islam Jemursari sebesar 294°3'5", Rumah Sakit Islam Surabaya sebesar 294° 3'6", dan Rumah Sakit Al-Irsyad Surabaya sebesar 294°3' 5". Namun demikian, terdapat perbedaan antara perhitungan dan pengukuran di lapangan sebesar 2°–7° termasuk dalam toleransi penyimpangan kiblat. Dapat disimpulkan ketiga metode ini secara akurat dapat menentukan arah kiblat di berbagai lokasi, namun pemeriksaan ulang diperlukan jika pengukuran melebihi batas toleransi.

***Keywords***: *Akurasi Kiblat; Spherical Trigonometri; Jean Meeus; Google Qibla Finder*

## A. Introduction

Prayer is one of the obligations that must be carried out by Muslims, where one of the legal requirements is facing the Qibla. Qibla direction is the direction Muslims use when performing prayers, which is towards the Kaaba, which is located in Mecca.[1] But in essence, this direction is not a standard or object of worship for Muslims because the thing in question is Allah SWT. "Qibla direction" itself consists of two words, namely direction and Qibla. In the Big Indonesian Dictionary (KBBI), demand has two meanings, namely "towards" and "facing". At the same time, the Qibla means the Kaaba, which is in Mecca.[2] For the people of Mecca, the order to face the Qibla is not a big problem because they can carry it out quickly. However, for Muslim communities who are far from the Mecca area, this is a big problem.[3] There are at least two obstacles in determining the Qibla direction—first, the person doing the measurement.[4] Second, the measuring instrument used. In the opinion of Imām Mālik, for people who are far from the Kaaba and do not know the Qibla direction, it is enough to face the Kaaba, according to estimates. [5]

[1] Nur Kosim and Muhammad Nur Hadi, 'Implementasi Gerakan Shalat Fardlu sebagai Motivasi Aspek Kesehatan', *Jurnal Mu'allim*, 1.1 (2019), 143–60.

[2] Nur Hidayatullah, *Masalatul Kiblat Fii Batawi* (Semarang: AlFaradis, 2021).

[3] Arino Bemi Sado, *Arah Kiblat: Suatu Kajian Syariah dan Sains Astronomi*, ed. by Muhammad Awaludin, 1st edn (Mataram: Sanabil, 2020).

[4] Muhammad Jawad Mughniyah, *Fiqih Lima Mazhab*, 28th edn (Jakarta: Lentera, 2011).

[5] Nurul Wakia and Sabriadi, 'Meretas Problematika Arah Kiblat Terkait Salat di Atas Kendaraan', *Elfalaky: Jurnal Ilmu Falak*, 4.2 (2020), 207.

From the explanation above, Qibla is very important to know the right direction. As for the letter explaining the Qibla direction in Sūrah Al-Baqarah/2:144

قَدْ نَرٰى تَقَلُّبَ وَجْهِكَ فِى السَّمَآءِۚ فَلَنُوَلِّيَنَّكَ قِبْلَةً تَرْضٰىهَاۗ فَوَلِّ وَجْهَكَ شَطْرَ الْمَسْجِدِ الْحَرَامِۗ وَحَيْثُ مَا كُنْتُمْ فَوَلُّوْا وُجُوْهَكُمْ شَطْرَهٗۗ وَاِنَّ الَّذِيْنَ اُوْتُوا الْكِتٰبَ لَيَعْلَمُوْنَ اَنَّهُ الْحَقُّ مِنْ رَّبِّهِمْۗ وَمَا اللّٰهُ بِغَافِلٍ عَمَّا يَعْمَلُوْنَ

> "We have certainly seen the turning of your face, [O Muḥammad], toward heaven, and We will surely turn you to a qiblah with which you will be pleased. So turn your face [i.e., yourself] toward al-Masjid al-Ḥarām. And wherever you [believers] are, turn your faces [i.e., yourselves] toward it [in prayer]. Indeed, those who have been given the Scripture [i.e., the Jews and the Christians] know that it is the truth from their Lord. And Allāh is not unaware of what they do."

The mosque is a place of worship for Muslims. However, other buildings that resemble mosques, such as langars and prayer rooms, are also places of worship for Muslims.[6] The growing presence of Muslims has resulted in many mosques and prayer rooms being erected in public places such as hospitals.[7] The hospital is one of the health facilities to provide health services to the community, so many people pass by in that location.[8] There are several types of hospitals, one of which is an Islamic hospital, namely a hospital that is based on Islamic law in its implementation, which is certain where there is a mosque or prayer room as a place of worship for Muslims, so calculations are needed in determining the Qibla direction systematically to avoid deviations. There are various methods for calculating the Qibla direction, including the Jean Meeus Method, the spherical trigonometry method, and the Google Qibla Finder Method.[9]

The Jean Meeus method uses the idea of simplifying the algorithm without decreasing the level of accuracy; in other words, this method makes calculations by looking for a value in units of seconds below zero so that it will not change the accuracy of the

[6] Dhiauddin Tanjung, *Ilmu Falak : Kajian Akurasi Arah Kiblat Kota Medan, Metode dan Solusi*, 1st edn (Medan: Perdana Publishing, 2018), I.

[7] Riki Suhendar, Titin Fatimah, and Rudy Trisno, 'Kajian Bentuk Masjid Tanpa Kubah Studi Kasus Masjid Al-Irsyad Bandung', *Jurnal Arsitektur dan Kota Berkelanjutan*, 2.1 (2020), 19–31 <https://jurnal.tau.ac.id/index.php/arsitekta/article/view/160>.

[8] Al Anfal, 'Pengaruh Kualitas Pelayanan dan Citra Rumah Sakit terhadap Tingkat Kepuasan Pasien Rawat Inap Rumah Sakit Umum Sundari Medan Tahun 2018', *Excellent Midwifery Journal*, 3.2 (2020), 1–19 <https://doi.org/10.55541/emj.v3i2.130>.

[9] Ahmad Mushonif dan Kutbuddin aibak, *Metode Penentuan dan Akurasi Arah Kiblat Masjid Masjid di Tulungagung*, ed. by Saiful Mustofa, 1st edn (Tulungagung: IAIN Tulungagung Press, 2018).

algorithm.[10] Measurements using the spherical trigonometry method utilize every point on the earth as on a spherical surface. [11] Three points are needed to perform calculations using this method: point A for the location of the Kaaba, point B for the place to be calculated, and point C, located at the North Pole. Google's Qibla Finder is an application launched by Google that helps make it easier for its users to find the Qibla direction by using the coordinates of the Kaaba as a reference for the current location. [12] The method used by Google's Qibla Finder is an implementation of the haversine method, which has a vital role in navigation. With so many ways, using the most accurate method is something that must be considered and necessary when making measurements because each method has advantages and disadvantages.

The research that has been done regarding the application of mathematics in determining the Qibla direction of the Tamhidi Center at the Islamic Science University of Malaysia using spherical trigonometry shows that the spherical trigonometry method will provide the best calculations for Muslims needed to find the Qibla direction. [13] Research on implementing the Jean Meeus algorithm to calculate the Qibla direction has found that the performance of this method in calculating the Qibla direction is entirely accurate. [14] Research that has been carried out regarding cooperative theory with Qibla Finder in the use of Qibla direction shows that in measuring Qibla direction using the Qibla Finder application, the level of accuracy must be reviewed with a more accurate falakiyah method due to factors such as signal network and weather which can cause the results measurements are inaccurate or there is a deviation. [15]

---

[10] Jean Meeus, *Astronomical Algorithms*, 2nd ed. (Virginia: Willmann-Bell, Inc., 1998).

[11] Taiping Zhang and others, 'A Solar Azimuth Formula That Renders Circumstantial Treatment Unnecessary without Compromising Mathematical Rigor: Mathematical Setup, Application and Extension of a Formula Based on the Subsolar Point and Atan2 Function', *Renewable Energy*, 172 (2021), 1333–40 <https://doi.org/10.1016/j.renene.2021.03.047>.

[12] 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*, 5.3 (2022), 147–64 <https://doi.org/10.20885/ijiis.vol.5.iss3.art2>.

[13] Siti Shapiee, Norrlaili; Faizah, 'Mathematical Application in Determining Qibla Direction of Tamhidi Centre Universiti Sains Islam Malaysia (Usim) By Using Spherical Trigonometry', *Universiti Sains Islam Malaysia*, 44 (2022), 115–22.

[14] Dinar Esti Mulyani, 'Penerapan Algoritma Deklinasi Matahari dan Equation of Time Jean Meeus Low Accuracy untuk Menentukan Arah Kiblat', *UIN Walisongo Semarang* (2022).

[15] Hanan Abimanyu, 'Komparasi Teori Raṣd Al-Qiblah dengan Qibla Finder dalam Pengukuran Arah Kiblat di Musala Al-Hijrah Desa Balerejo Kecamatan Kebonsari Kabupaten Madiun', *Etheses.Iainponorogo* (2022).

Based on the background that has been described, with references from previous studies and updates to this research, this research aims to compare the difference in Qibla angles produced by the spherical trigonometry method, Jean Meeus algorithm, and Google's qibla finder with measurements field as well as analyzing the factors that can affect the differences in the accuracy of these calculations with field results at Jemursari Islamic Hospital, Surabaya Islamic Hospital, and Al-Irsyad Hospital Surabaya.

## B. Method

The methods in this research are the spherical trigonometry method, Jean Meeus algorithm, and Qibla Finder Google in RSI Jemursari, RSI Surabaya, and RS Al-Irsyad Surabaya. The three hospitals are operated under Islamic law. The three hospitals are run based on Islamic law. Data for this research using latitude and longitude data of a location to be studied. As for the research as in table 1.

Table 1
Research Data

| | **Jemursari Islamic Hospital** | **Surabaya Islamic Hospital** | **Surabaya Al-Irsyad Hospital** |
|---|---|---|---|
| latitude | -7.322401283 | -7.323351373 | -7.227799665 |
| longitude | 112.739767 | 112.7407167 | 112.7403766 |

The steps in this research are as follows:

### 1. Latitude and Longitude Data for the Three Mosques

a. Jemursari Islamic Hospital

There are several Islamic hospitals in Surabaya, one of which is the Islamic Hospital Jemursari, located in the Woncolo district of Surabaya, with a latitude of -7° 18" 21"South and a longitude of 112° 44" 8" East. To coincide with the Prophet Muhammad's birth anniversary on September 25, 2002, this hospital was created from the principles of Islamic law. This hospital has seen a great deal of development and expansion of facilities and infrastructure over the years.

b. Surabaya Islamic Hospital

Surabaya Islamic Hospital is one of the most complex medical institutions with many doctors whose entire activity is based on Islamic law. To carry out activities that involve many aspects, the hospital must have personnel who are trained in the field

of medical technology and health management. [16] The hospital started operating on March 25 1975 and can accommodate 40 beds. The hospital class is classified as middle class. It is located at Ahmad Yani Street, Wonokromo District, Surabaya and at latitude -7° 18" 23.094" LS and longitude 112° 44' 8" East.

c. Surabaya Al-Irsyad Hospital

Al-Irsyad Hospital is the oldest hospital, established in 1978 in Ampel Surabaya. The background of the establishment of this hospital was the result of the clashes between the people of Surabaya, especially North Surabaya, which caused many casualties. On the initiative of the youth, doctors, and some community leaders led by Mr Hasan Achmad Baktir BA, the first hospital in North Surabaya was established. At the beginning of its establishment, this hospital only had Mother and Child Services (KIA) and ER. However, over time, this hospital proliferated. In 2006, there was dialysis equipment for people with kidney problems (haemodialysis). Al-Irsyad Hospital is the first hospital in East Java to have haemodialysis. This hospital is located at Jl. Dana Karya no.28, Surabaya, East Java, is located on a latitude of -7° 13" 40" LS and longitude 112° 44' 25" East.

## 2. Calculate With Several Methods

### a. Spherical Trigonometry Method

Spherical trigonometry is the study of the ratio of the lengths of right triangles, including cosines, tangents, and sines, a branch of mathematics.[17] The branch of Trigonometry is spherical trigonometry, which examines the relationship between the angles and the sides of a spherical triangle.[18] Spherical trigonometry can be

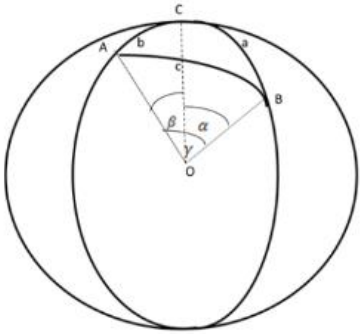
[16] Dhinta Feritsya Chita, Wasis Budiarto, and C. Sri Hartati, 'Analisis Pengaruh Pengalaman Kerja dan Pelatihan Terhadap Mutu Pelayanan dan Kinerja Tenaga Kesehatan Rumah Sakit Islam (Rsi) Surabaya', *Ekonomika45 : Jurnal Ilmiah Manajemen, Ekonomi Bisnis, Kewirausahaan*, 9.2 (2022), 151–62.

[17] Herlina Ahmad, Febryanti Febryanti, and Nurfaida Tasni, 'Integrasi Alquran pada Mata Kuliah Trigonometri', *Jurnal Pendidikan Matematika*, 14.1 (2019), 25–38 <https://doi.org/10.22342/jpm.14.1.6768.25-38>.

[18] W. S.Mada Sanjaya and others, 'Determining Qibla Direction Using Al-Biruni's First Method from Kitab Tahdid Nihayat Al-Amakin with the Implementation Based on Board Arduino MCU, GPS Module, and Digital Compass', *Proceedings - 2019 International Seminar on Application for Technology of Information and Communication: Industry 4.0: Retrospect, Prospect, and Challenges, ISemantic 2019*, 2019, 513–18.

implemented in determining the Qibla direction. To obtain an accurate Qibla direction, use the spherical trigonometry formula as shown in Figure 1 below: [19]

Figure 1
Spherical trigonometry




Based on Figure 1 above, a spherical triangle ABC has angles <ABC, <CAB, and <BCA and lengths a, b, and c.

1) The centre of Qibla direction is implemented at point A with longitude (λ) and a certain latitude (ϕ), which can be denoted $\phi_A$ and $\lambda_A$. The location where the Qibla direction will be calculated is indicated as Point B with a specific longitude (λ) and latitude (ϕ), which can be symbolized as $\phi_B$ and $\lambda_B$. Point C is the location of the North Pole by calculating the difference between latitudes or can be written $\lambda_A$-$\lambda_B$.
2) Triangle ABC has sides of length a, b, and c. The length of each side can be written as follows:

$$a = 90° - \phi_B$$

$$b = 90° - \phi_A$$

$$c = \lambda_A - \lambda_B$$

So, the formula of spherical trigonometry in determining the Qibla direction is as follows: [20]

$$tan\ B\ = \frac{sin\ C}{(sin\ a\ :\ tan\ b\ -\ cos\ a\ cos\ C)}$$

**b. Jean Meeus Method**

Jean Meeus is an algorithm from the reduction of VSOPB7 and then used to determine the sun's position. In addition, this algorithm can also be used to

[19] Syukron Kamal and Muslich Shabir, 'Application of Effective Azimuth Different', *Al-Hilal: Journal of Islamic Astronomy*, 4.2 (2022).

[20] Agus Solikin, 'Telaah Matematis Perhitungan Arah Kiblat Rumus Cos-Sin dengan Rumus Tan dalam Dasar-Dasar Ilmu Ukur Segitiga Bola', *Al-Marshad: Jurnal Astronomi Islam dan Ilmu-Ilmu Berkaitan*, 6.2 (2020), 138–48.

determine solar eclipses, moon positions, new moons, measure parameters to ensure the start time of prayer and calculate Qibla direction. Dinar Esti Mulyani has carried out previous research using the Jean Meeus algorithm titled Application of the Solar Declination Algorithm and Jean Meeus Low Accuracy Equation of Time to determine Qibla direction. From this research, it was found that the Jean Meeus algorithm is entirely accurate in calculating the Qibla direction because it has a slight difference.

When using Jean Meeus' algorithm calculations, some data must be prepared first, so that it is easier to apply to the formula.The data required include the latitude of the Kaaba, the longitude of the Kaaba, the latitude of the place, the longitude of the Kaaba place and so on.[21]

The calculation process is as follows:

1) Prepare the necessary data such as latitude of place, longitude of location, longitude of region, latitude of Kaaba, and longitude of Kaaba.
2) Calculating Qibla direction (B) and Qibla Azimuth with the formula as in the following equation:

$$Tan\ B\ = \frac{Sin\ C}{Cos\ LT\ \times Tan\ LK - Sin\ LT\ \times Cos\ C}$$

Description:

B : Qibla Direction
LK (Φk) : Latitude of the Kaaba
LT (Φx) : Latitude of Place
C : Difference in Longitude

Determining the Qibla azimuth can use the following conditions:

a) If x is positive (+) and y is positive (+), Tan B is positive (+), which results in 0 < B < 90. Then, the result can be determined as the qibla azimuth.
b) If x is negative (-) and y is positive (+), Tan B is negative (-), which results in 90 < B < 180. Then the qibla azimuth = 180 - B.
c) If x is negative (-) and y is negative (-), Tan B is positive (+), which results in 180 < B < 270. Then the Qibla azimuth = 180 + B.

[21] Mira Musrini Barmawi, Muhammad Ichwan, and Rara Restu Lukito, 'Implementasi Algoritma Jean Meeus dalam Menentukan Waktu Shalat', *MIND Journal*, 2.1 (2018), 26–33 <https://doi.org/10.26760/mindjournal.v2i1.26-33>.

d) If x is positive (+) and y is negative (-), Tan B is negative (-), which results in 270 < B < 360. Then the qibla azimuth = 360 + B.

**c. Google Qibla Finder Method**

Qibla Finder Google is a website or application managed by Google that aims to find the Qibla direction for all Muslims who want to carry out the obligation to pray. The data required is to use the coordinates of the Kaaba (latitude 21.4224779; Longitude 39.8251832) as a reference and the current location to determine the most precise direction directly to the Kaaba between two points, which is also known as the great circle distance. Google's Qibla Finder works with the device's compass and camera to ensure the accuracy of its directions. [22]

The method used by Qibla Finder Google is calculated using the haversine formula. [23] The haversine method is an equation that plays a vital role in the navigation field that produces the shortest distance between two points taken from longitude and latitude.[24] The haversine formula can calculate the distance between two points based on the latitude and longitude positions as input variables. [25] The haversine formula is an application of trigonometric concepts related to geometry. It is a unique form of the equation from spherical trigonometry. The haversine formula is applied to find the relationship of sides and angles in triangles in a spherical shape. One of the trigonometric rules used is the cosine rule. This formula is accurate enough for most calculations. However, it also ignores the height of hills and the

[22] Maulidin and Abdullah, 'Uji Komparasi Instrumen Arah Kiblat Antara Qibla Tracker dan Mizwala Qibla Finder', *Astroislamica: Journal of Islamic Astronomy*, 1.1 (2022), 73–96 <https://doi.org/10.47766/astroislamica.v1i1.899>

[23] Bo Yi Dunque, Kristine Mae Paboreal; See, Aaron Raymond; Putra, Dwi Sudarno; Lin, Rong Da; Li, 'Obstacle Detector and Qibla Finder for Visually Impaired Muslim Community', *ICBME 2019: 17th International Conference on Biomedical Engineering*, 79 (2021), 55–71.

[24] Malik Bashir Ahmad Bagvi, *Determination of the Direction of Qibla and the Islamic Timings* (Michigan: Printed at Pak-Arts, 1970).

[25] Asrul Azhari Muin, Muhammad Syafei, and Akhmad Qashlim, 'Implementasi Formula Haversine Pada Sistem Informasi Guru Mengaji Private', *Jurnal Ilmiah Ilmu Komputer*, 6.2 (2020), 60–66.

depth of valleys at ground level. [26] The following is the form of the haversine formula as in the equation below: [27]

$$\Delta lat = lat_2 - lat_1$$
$$\Delta long = long_2 - long_1$$
$$a = sin^2\left(\frac{\Delta lat}{2}\right) + \cos(lat_1)\cos(lat_2)sin^2\left(\frac{\Delta long}{2}\right)$$
$$c = 2\frac{1}{\tan(\frac{\sqrt{1-a}}{\sqrt{a}})}$$
$$y = \sin(\Delta long) \times \cos(lat_2)$$
$$x = \cos(lat_1)\sin(lat_2) - \sin(lat_1) \times \cos(lat_2) \times \cos(\Delta long)$$
$$azimuth = \frac{1}{\tan(\frac{y}{x})}$$

Description:

| | |
|---|---|
| $lat_1$ | : latitude of the place (mosque) |
| $lat_2$ | : the latitude of the Kaaba |
| $\Delta lat$ | : the amount of latitude change |
| $long_1$ | : longitude of the place (mosque) |
| $long_2$ | : longitude of the *Kaaba* |
| $\Delta Long$ | : the amount of difference in longitude |
| C | : axis intersection calculation |

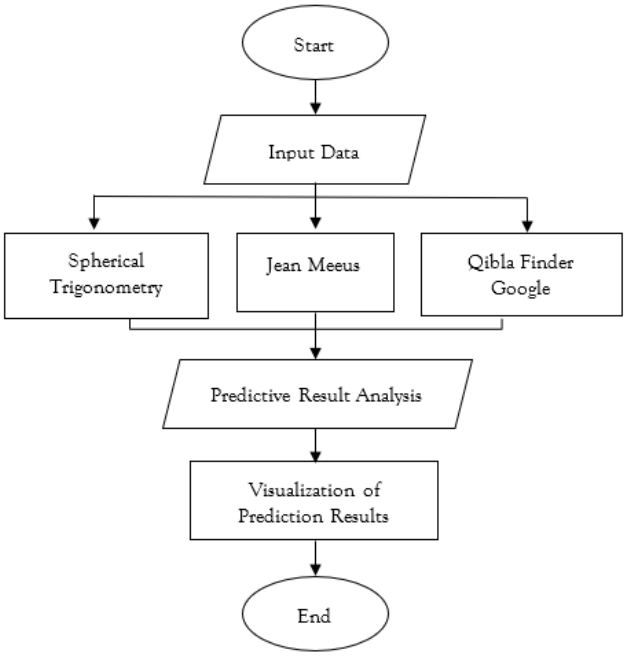
3. Analyze the comparison of the calculation results of several methods
4. Visualizing the calculation results with a circle graph that resembles a compass.

The flowchart in this study is as in Figure 2.

[26] Sarif Ifan Purnawan, Fitri Marisa, and Indra Dharma Wijaya, 'Aplikasi Pencarian Pariwisata dan Tempat Oleh-Oleh Terdekat Menggunakan Metode Haversine Berbasis Android', *J I M P - Jurnal Informatika Merdeka Pasuruan*, 3.2 (2018), 9–16.

[27] Agus Solikin, 'Pertemuan Rumus Cosinus dan Sinus dengan Haversine dalam Perhitungan Arah Kiblat', *Teorema: Teori dan Riset Matematika*, 5.2 (2020), 211.

Figure 2
Research Flowchart




## C. Result and Discussion

### 1. Qibla Direction Calculation Accuracy

Table 2
Qibla Direction Calculation Results

| | Spherical Trigonometry Method | Jean Meeus Algorithm | Qibla Finder Google |
|---|---|---|---|
| Jemursari Islamic Hospital | 294° 3 5" | 294° 3 5" | 294° 3 5" |
| Surabaya Islamic Hospital | 294° 3 6" | 294° 3 6" | 294° 3 6" |
| Al-Irsyad Hospital in Surabaya | 294° 1' 53" | 294° 1' 53" | 294° 1' 53" |

Based on Table 2, the results of calculating the Qibla direction can be seen using three methods, namely the spherical Trigonometry Method, the Jean Meeus Method, and the Google Qibla Finder Method, which has the same results, namely at Jemursari Islamic Hospital at 294° 3' 5", at Surabaya Islamic Hospital at 294 ° 3' 6", and at A-l-Irsyad Hospital Surabaya by 294° 3' 5". At the three hospitals the difference in measurement results is 0° 0' 1" to 0° 2' 48" due to differences in latitude and longitude So that the three methods have accurate results in measuring the Qibla direction.

## 2. Comparison of Calculation Results

Table 3

Comparison of Calculation Results with Field Measurements

| | The Calculation Results | Field Measurement | difference |
|---|---|---|---|
| Jemursari Islamic Hospital | 294° | 301° | 7° |
| Surabaya Islamic Hospital | 294° | 290° | 4° |
| Al-Irsyad Hospital in Surabaya | 294° | 292° | 2° |

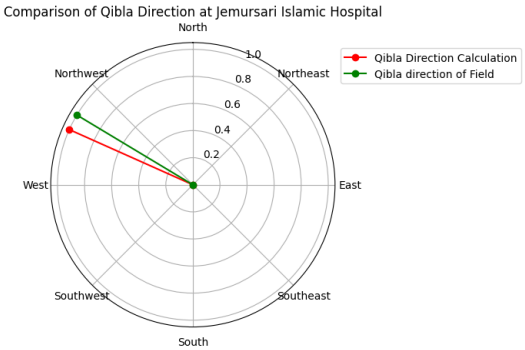
Based on Table 3, the Jemursari Islamic Hospital has a field measurement value of 301°, more significant than the calculated result of 294°, so there is a substantial difference in the Qibla direction angle, namely 7°. The Surabaya Islamic Hospital has a field measurement value of 290°, which is smaller than the calculation result of 294°, so there is a difference in the Qibla direction angle of 4°. At Al-Irsyad Hospital in Surabaya, it has a field measurement value of 292°, which is smaller than the calculation result of 294°, so there is a relatively small difference in the Qibla direction angle of 2°. Based on this, it can be concluded that the difference between field measurements and calculations is 2°- 7°, which results are still within the tolerance of the Qibla deviation so that the Qibla direction is accurate.

## 3. Visualization of Calculation Results

a. Measurements at Jemursari Islamic Hospital

Figure 3

The results of the comparison of Qibla direction at the Jemursari Islamic Hospital

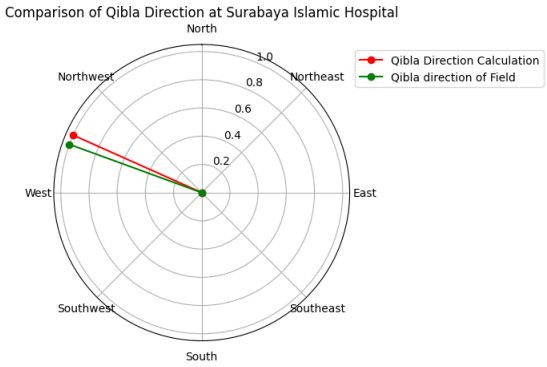



Based on Figure 3, it can be seen that the red point is the result of calculating the Qibla direction, namely with an angle of 294°—the green energy results from field

measurements with an angle of 301°. There is a considerable distance between points, and this is because the difference between these results is 7°.

b. Measurements at Surabaya Islamic Hospital

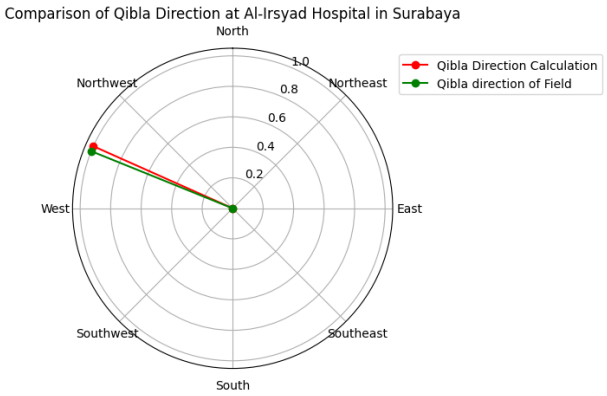
Figure 4
The results of the comparison of Qibla direction at the Surabaya Islamic Hospital




Based on Figure 4, it can be seen that the red point is the result of calculating the Qibla direction, namely with an angle of 294°—the green point results from field measurements with an angle of 290°. There is a distance between points that is not too far away; this is because the difference between these results is 4°.

c. Measurements at the Al-Irsyad Hospital in Surabaya

Figure 5
The results of the comparison of Qibla direction at the Al-Irsyad Hospital in Surabaya




Based on Figure 5, it can be seen that the red dot is the result of calculating the Qibla direction with an angle of 294°—the green dot results from field measurements with an angle of 292°. There is a distance between points that coincide, and this is because the difference between these results is 2 °.

### 4. Evaluation of calculation results

From the results described above, the cause of the difference in Qibla direction is the ignorance of most people about the importance of performing prayers in the order of the Qibla. What leads to the correct Qibla is one of the conditions for a valid prayer. This difference is also due to selfishness.[28] Each party responded to the existing truth, even though the Indonesian Ulema Council (MUI) has issued a fatwa regarding the Qibla direction that the Qibla direction for Indonesian areas is to the Northwest with a slope that varies in each room. The Spherical Trigonometry Method, the Jean Meeus Method, and the Google Qibla Finder Method use initial measurements with latitude and longitude data from each hospital and the Kaaba that are entered into the formula for each method, where the results will never change if there is no displacement of the position of the measurement location and the position of the Kaaba. The three methods have been implemented accurately. Likewise, in-field measurements use a compass adjusted to the Qibla direction at each location to determine the differences in calculations using mathematical methods and field measurements.

Qibla direction differences can arise due to various geographical and astronomical factors. Variations in latitude and longitude where the observer is located compared to the main Qibla in Mecca, as well as changes in the sun's position over time, can cause a tilt in the direction of the Qibla. In addition, the earth's magnetic phenomena can also affect the compass and cause a significant difference in approach. In the context of fiqh, knowledge of the correct Qibla direction is essential in carrying out prayer services. Therefore, systematic calculations and measurements in the field are critical approaches to overcome the possible tilt of the Qibla direction. Through GPS technology, the selection of accurate observation points can be made, and field measurements will help verify the actual Qibla direction at that location.

## D. Conclusion

Based on the discussion, after carrying out calculations to determine the Qibla direction at three Islamic hospitals in Surabaya, namely Jemursai Islamic Hospital, Surabaya

[28] Rizki Muhammad Haris, 'Tinjauan Maqashid Syari'ah terhadap Pelaksanaan Salat Berjamaah dengan Menghadap Dua Arah Kiblat', *Al-Usrah : Jurnal Al-Ahwal As-Syakhsiyah*, 10.01 (2022).

Islamic Hospital, Surabaya Al-Irsyad Hospital with three methods, namely the spherical Trigonometry method, the Jean Meeus method, and the Qibla Finder method Google obtained the same results and did not differ significantly in the calculation results compared to the field measurement results. There are differences in the calculation results between the three locations; this is due to the different latitude and longitude values, and there are differences between the effects of calculations and field measurements, namely in the range of 2°—7° where the results are still within the tolerance of Qibla deviation, it can be concluded that Calculations using these three methods are accurate for determining Qibla direction so that they can be applied to different locations and if these results are found to have a difference of <90°, it is necessary to re-check the Qibla direction at that location because of differences in measurement results.

## E. Bibliography

Abimanyu, Hanan, 'Komparasi Teori Raṣd Al-Qiblah dengan Qibla Finder dalam Pengukuran Arah Kiblat di Musala Al-Hijrah Desa Balerejo Kecamatan Kebonsari Kabupaten Madiun', *Etheses.Iainponorogo* (IAIN Ponorogo, 2022) <http://etheses.iainponorogo.ac.id/18454/2/Skripsi Upload Etheses.pdf>

Ahmad, Herlina, Febryanti Febryanti, and Nurfaida Tasni, 'Integrasi Alquran Pada Mata Kuliah Trigonometri', *Jurnal Pendidikan Matematika*, 14.1 (2019), 25–38 <https://doi.org/10.22342/jpm.14.1.6768.25-38>

Ahmad Mushonif dan Kutbuddin aibak, *Metode Penentuan dan Akurasi Arah Kiblat Masjid Masjid di Tulungagung*, ed. by Saiful Mustofa, 1st edn (Tulungagung: IAIN Tulungagung Press, 2018)

Anfal, Al, 'Pengaruh Kualitas Pelayanan dan Citra Rumah Sakit Terhadap Tingkat Kepuasan Pasien Rawat Inap Rumah Sakit Umum Sundari Medan Tahun 2018', *Excellent Midwifery Journal*, 3.2 (2020), 1–19 <https://doi.org/10.55541/emj.v3i2.130>

Bagvi, Malik Bashir Ahmad, *Determination of the Direction of Qibla and the Islamic Timings* (Michigan: Printed at Pak-Arts, 1970)

Barmawi, Mira Musrini, Muhammad Ichwan, and Rara Restu Lukito, 'Implementasi Algoritma Jean Meeus dalam Menentukan Waktu Shalat', *MIND Journal*, 2.1 (2018), 26–33 <https://doi.org/10.26760/mindjournal.v2i1.26-33>

Budiwati, Anisah, 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*, 5.3 (2022), 147–64 <https://doi.org/10.20885/ijiis.vol.5.iss3.art2>

Dhinta Feritsya Chita, Wasis Budiarto, and C. Sri Hartati, 'Analisis Pengaruh Pengalaman Kerja dan Pelatihan Terhadap Mutu Pelayanan dan Kinerja Tenaga Kesehatan Rumah Sakit Islam (Rsi) Surabaya', *EKONOMIKA45 : Jurnal Ilmiah Manajemen, Ekonomi Bisnis, Kewirausahaan*, 9.2 (2022), 151–62

<https://doi.org/10.30640/ekonomika45.v9i2.216>

Dunque, Kristine Mae Paboreal; See, Aaron Raymond; Putra, Dwi Sudarno; Lin, Rong Da; Li, Bo Yi, 'Obstacle Detector and Qibla Finder for Visually Impaired Muslim Community', *ICBME 2019: 17th International Conference on Biomedical Engineering*, 79 (2021), 55–71 <https://link.springer.com/chapter/10.1007/978-3-030-62045-5_6> [accessed 7 July 2023]

Haris, Rizki Muhammad, 'Tinjauan Maqashid Syari'ah terhadap Pelaksanaan Salat Berjamaah dengan Menghadap Dua Arah Kiblat', *Al-Usrah : Jurnal Al-Ahwal As-Syakhsiyah*, 10.01 (2022)

Hidayatullah, Nur, *Masalatul Kiblat Fi Batawi* (Semarang: AlFaradis, 2021)

Kamal, Syukron, and Muslich Shabir, 'Application of Effective Azimuth Different', *Al-Hilal: Journal of Islamic Astronomy*, 4.2 (2022) <https://journal.walisongo.ac.id/index.php/al-hilal/article/view/12069/4710>

Kosim, Nur, and Muhammad Nur Hadi, 'Implementasi Gerakan Shalat Fardlu sebagai Motivasi Aspek Kesehatan', *Jurnal Mu'allim*, 1.1 (2019), 143–60 <https://doi.org/10.35891/muallim.v1i1.1357>

Maulidin, and Abdullah, 'Uji Komparasi Instrumen Arah Kiblat Antara Qibla Tracker Dan Mizwala Qibla Finder', ASTROISLAMICA : Journal of Islamic Astronomy, 1.1 (2022), 73–96 <https://doi.org/10.47766/astroislamica.v1i1.899>

Meeus, Jean, *Astronomical Algorithms*, 2nd ed. (Virginia: Willmann-Bell, Inc., 1998)

Mughniyah, Muhammad Jawad, *Fiqih Lima Mazhab*, 28th edn (Jakarta: Lentera, 2011)

Muin, Asrul Azhari, Muhammad Syafei, and Akhmad Qashlim, 'Implementasi Formula Haversine pada Sistem Informasi Guru Mengaji Private', *Jurnal Ilmiah Ilmu Komputer*, 6.2 (2020), 60–66

Mulyani, Dinar Esti, 'Penerapan Algoritma Deklinasi Matahari dan Equation of Time Jean Meeus Low Accuracy Untuk Menentukan Arah Kiblat', *UIN Walisongo Semarang* (UIN Walisongo Semarang, 2022) <https://eprints.walisongo.ac.id/id/eprint/18037/1/Skripsi_1802046086_Dinar_Esti_Mulyani.pdf>

Purnawan, Sarif Ifan, Fitri Marisa, and Indra Dharma Wijaya, 'Aplikasi Pencarian Pariwisata dan Tempat Oleh-Oleh Terdekat Menggunakan Metode Haversine Berbasis Android', *J I M P - Jurnal Informatika Merdeka Pasuruan*, 3.2 (2018), 9–16 <https://doi.org/10.37438/jimp.v3i2.166>

Sado, Arino Bemi, *Arah Kiblat: Suatu Kajian Syariah dan Sains Astronomi*, ed. by Muhammad Awaludin, 1st edn (Mataram: Sanabil, 2020)

Sanjaya, W. S.Mada, Akhmad Roziqin, Astuti Kusumorini, Dyah Anggraeni, Fikri Ibrahim Nurrahman, Winandar Ganis Kresnadjaja, and others, 'Determining Qibla Direction Using Al-Biruni's First Method from Kitab Tahdid Nihayat Al-Amakin with the Implementation Based on Board Arduino MCU, GPS Module, and Digital Compass', *Proceedings - 2019 International Seminar on Application for Technology of Information and Communication: Industry 4.0: Retrospect, Prospect, and Challenges, ISemantic 2019*, 2019, 513–18 <https://doi.org/10.1109/Isemantic.2019.8884330>

Shapiee, Norrlaili; Faizah, Siti, 'Mathematical Application in Determining Qibla Direction of Tamhidi Centre Universiti Sains Islam Malaysia (Usim) By Using Spherical Trigonometry', *Universiti Sains Islam Malaysia*, 44 (2022), 115–22 <https://oarep.usim.edu.my/jspui/bitstream/123456789/19549/1/Mathematical

Application In Determining Qibla Direction Of Tamhidi Centre Universiti Sains Islam Malaysia %28USIM%29 By Using Spherical Trigonometry.pdf>

Solikin, Agus, 'Pertemuan Rumus Cosinus dan Sinus dengan Haversine dalam Perhitungan Arah Kiblat', *Teorema: Teori dan Riset Matematika*, 5.2 (2020), 211 <https://doi.org/10.25157/teorema.v5i2.3671>

——, 'Telaah Matematis Perhitungan Arah Kiblat Rumus Cos-Sin dengan Rumus Tan dalam Dasar-Dasar Ilmu Ukur Segitiga Bola', *Al-Marshad: Jurnal Astronomi Islam dan Ilmu-Ilmu Berkaitan*, 6.2 (2020), 138–48 <https://doi.org/10.30596/jam.v6i2.5023>

Suhendar, Riki, Titin Fatimah, and Rudy Trisno, 'Kajian Bentuk Masjid Tanpa Kubah Studi Kasus Masjid Al-Irsyad Bandung', *Jurnal Arsitektur dan Kota Berkelanjutan*, 2.1 (2020), 19–31 <https://jurnal.tau.ac.id/index.php/arsitekta/article/view/160>

Tanjung, Dhiauddin, *Ilmu Falak : Kajian Akurasi Arah Kiblat Kota Medan, Metode dan Solusi*, 1st edn (Medan: Perdana Publishing, 2018), I

Wakia, Nurul, and Sabriadi, 'Meretas Problematika Arah Kiblat Terkait Salat di Atas Kendaraan', *Elfalaky: Jurnal Ilmu Falak*, 4.2 (2020), 207 <https://journal3.uin-alauddin.ac.id/index.php/elfalaky/article/view/18089>

Zhang, Taiping, Paul W. Stackhouse, Bradley Macpherson, and J. Colleen Mikovitz, 'A Solar Azimuth Formula That Renders Circumstantial Treatment Unnecessary without Compromising Mathematical Rigor: Mathematical Setup, Application and Extension of a Formula Based on the Subsolar Point and Atan2 Function', *Renewable Energy*, 172 (2021), 1333–40 <https://doi.org/10.1016/j.renene.2021.03.047>

This page has been intentionally left blank