THE UTILIZATION OF AUGMENTED REALITY TECHNOLOGY IN DETERMINING QIBLA DIRECTION (ANALYSIS OF MIQAT APPLICATIONS BY SAMER JOUDI)

Naufal Fazal Muttaqin
Pascasarjana Universitas Islam Negeri Walisongo Semarang-Indonesia
naufalfmuttaqin@gmail.com

Abstract:

One application for determining Qibla direction based on Android and augmented reality technology is Miqat: Prayer Times, Qiblah, and Hilal Visibility, which was released in 2015 by Samer Joudi. The application has a 3D Qibla feature that directs users toward the Ka'ba with the help of augmented reality technology in an actual reality display. Through a descriptive-qualitative method with field research, this article aims to determine the accuracy of the Miqat application in deciding the Qibla direction. This article finds two things. First, the Miqat application uses the Vincenty formula as a reasonably accurate calculation method (7 minutes difference from calculating the Istiwa'aini Qibla direction). Second, determining the Qibla direction using the 3D Qibla feature with augmented reality technology is categorized as less accurate according to Slamet Hambali's level of accuracy. It is still within tolerance limits, according to Thomas Djamaluddin's level of accuracy. The accuracy of the Qibla direction of the Miqat application differs from 0o to 1o from the Qibla direction measured by Istiwa'aini.

Keywords: Qibla, Augmented Reality, Miqat, Vincenty

Abstrak:

Salah satu aplikasi penentuan arah kiblat berbasis android dan teknologi augmented reality yaitu Miqat: Prayer Times, Qiblah, and Hilal Visibility yang dirilis pada tahun 2015 oleh Samer Joudi. Aplikasi tersebut memiliki fitur 3D Qibla yang berfungsi untuk mengarahkan pengguna ke arah Kakbah dengan bantuan teknologi *augmented reality* dalam tampilan realitas nyata. Melalui metode deskriptif-kualitatif dengan data lapangan, artikel ini bertujuan untuk mengetahui akurasi aplikasi Miqat dalam menentukan arah kiblat. Artikel ini menemukan dua hal. Pertama, aplikasi Miqat menggunakan rumus *vincenty* sebagai metode perhitungan yang cukup akurat (selisih 7 menit dengan perhitungan arah kiblat *istiwa'aini*). Kedua, penentuan arah kiblat menggunakan fitur 3D Qibla yang berteknologi augmented reality, meskipun dikategorikan kurang akurat menurut tingkat keakuratan Slamet Hambali, namun masih dalam batas toleransi menurut tingkat keakuratan Thomas Djamaluddin. Tingkat akurasi arah kiblat aplikasi Miqat ini berselisih 0o hinga 1o dari arah kiblat hasil pengukuran *istiwa'aini*.

Keywords: Arah Kiblat, Augmented Reality, Miqat, Vincenty

A. Introduction

Facing the Qibla is mandatory, especially when performing prayer services, both obligatory and sunnah prayers.[1] The implementation of worship has become a must for every Muslim to face towards the Kaaba.[2] The Kaaba is a direction that unites the direction of all Muslims in performing prayers.[3] The obligation to face the Qibla, namely the Kaaba in the Grand Mosque, is implied in the word of Allah in QS. Al-*Baqarah* [2]:149 :

وَمِنْ حَيْثُ خَرَجْتَ فَوَلِّ وَجْهَكَ شَطْرَ الْمَسْجِدِ الْحَرَامِ ۖ وَإِنَّهُ لَلْحَقُّ مِنْ رَبِّكَ ۗ وَمَا اللَّهُ بِغَافِلٍ عَمَّا تَعْمَلُونَ

> "Indeed, We (often) see your face looking up to the sky, so indeed, We will turn you to the Qibla that you like. Turn your face towards the Masjidil Haram. Every where you are, turn your face on him. And actually those people (Jews and Christians) who were given the Al-Kitab (Torah and Bible) do know that turning to the Grand Mosque is true from their Lord; and Allah is by no means unaware of what they do."[4]

Existing *shar'ī* arguments show that Muslims have agreed that facing the Qiblah is a requirement for the legitimacy of prayer. [5] The command to pray facing the direction of the Grand Mosque is repeated in the next verse, namely *Sūrah* Al-Baqarah [2]: 150. This verse explains that the order is general for all people, times and places so that there is no more reason for the people of the book, the polytheists and the hypocrites to oppose the Prophet. in the matter of moving the qibla.[6] Facing the Qiblah for those who can see the Kaaba is facing the Kaaba building (*'ayn al-ka'bah*). However, if people who are far from the area of the Grand Mosque and even far from Arabia, there are differences of opinion. There are those who are allowed to face the direction only (*jihah al-ka'bah*) and there are also those who require facing the Kaaba building (*'ayn al-ka'bah*).

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[1] Ma'rufin Sudibyo, *Sang Nabi pun Berputar (Arah Kiblat dan Tata Cara Pengukurannya*, (Solo: Tinta Medina, 2011), 92.

[2] Slamet Hambali, *Ilmu Falak 1 (Penentuan Awal Waktu Shalat dan Arah Kiblat Seluruh Dunia)*, (Semarang: Program Pascasarjana IAIN Walisongo Semarang, 2011), 167.

[3] Achmad Jaelani, *et al, Hisab Rukyat Menghadap Kiblat (Fiqh, Aplikasi, Praktis, Fatwa dan Software)*, (Semarang: Pustaka Rizki Putra, 2012), 1.

[4] Al-Qur'an al-Karim dan Terjemahnya, (Kudus: Menara Kudus, 2006), 23.

[5] Muhyiddin Khazin, *Ilmu Falak dalam Teori dan Praktik*, (Yogyakarta: Buana Pusaka, 2004), 47.

[6] Kementerian Agama RI, *al-Qur'an dan Tafsirnya*, (Jakarta: Kementerian Agama RI dengan biaya DIPA, 2012), 229-230.

The direction of the Qibla has always undergone periodic development, particularly in Indonesia, depending on the level of knowledge, quality, and intellectual capacity that the Islamic community possessed at the time. The numerous instruments and astronomical measurement techniques used to determine the direction of the Qibla provide as evidence for this. going from instruments and procedures with low accuracy levels to high precision levels. These instruments range from the Theodolite, whose precision has been acknowledged by astronomers, to the Compass, Istiwa Stick, *Rubu' Mujayyab*, Global Positioning System (GPS), *Istiwa'aini*, and *Mizwala* Qibla Finder. While the method of determining the Qibla direction is by calculating *Rubu' Mujayyab*, the right-angled triangle method from the sun's shadow at any time, as well as the *Rasdhul Qibla* method. Determining the Qibla direction can also be done by utilizing the azimuth of celestial bodies such as stars and planets, and utilizing the shadows of objects that are cast sunlight. Determining Qibla direction can also be developed digitally, namely by combining previous methods of determining Qibla direction with technological developments such as making digital instrumentation to determine Qibla direction such as theodolites, calculations that utilize computing systems, making applications for determining Qibla direction on computers and smartphones.[7]

The general public prefers to establish the Qibla direction in the simplest way possible rather than using any of the several tools or methods mentioned above for doing so, with the exception of astronomers. One of them is using the Qibla direction application which is accessed via an Android smartphone. Qibla direction applications on smartphones are quite widely available on Google's application distribution platform, namely the Google Play Store and on Apple Inc's application distribution platform, namely the App Store. Qibla direction applications are also available on various web pages on the Internet, both web-based applications and applications that can be downloaded for smartphones. These applications usually utilize a magnetic compass, GPS, and satellite imagery in determining the Qibla direction. Most recently, there is now a Qibla direction determination using an android application with Augmented Reality technology.

[7] Muhammad Thoyfur, *Digitalisasi Rasdhul Kiblat Lokal oleh Qibla Diagram*, (Semarang: Jurnal Al-Hilal UIN Walisongo, Volume 3, Nomor 1, Maret 2021).

According to Anisah Budiwati's research in 2016, in the form of a journal entitled "Stick of *Istiwa'*, Global Positioning System (GPS) and Google Earth to Determine Earth's Coordinate Points and Their Application in Determining Qibla Direction".[8] According to the study's findings, GPS and Google Earth employ more exact geodetic scientific principles to determine the Earth's coordinates, but the istiwa stick uses a simpler spherical trigonometry calculation approach. In terms of application, the most practical and accurate is GPS. Then followed by Google Earth, and special sticks.

Augmented Reality or AR can be abbreviated as a technology that combines two-dimensional and or three-dimensional virtual objects into a three-dimensional real environment and then projects these virtual objects in real time.[9] AR is a combination of virtual (virtual) and real (real) worlds created by computers. Virtual objects can be in the form of text, animation, 3D models or videos combined with the actual environment so that users feel that virtual objects are in their environment. According to Goel and Bhardwaj (2014) AR technology can run normally on mobile devices such as iPhones, iPads, smartphones, PCs, tablets and others.[10]

Unlike virtual reality which completely replaces reality, this AR technology only adds or complements reality. Virtual objects display information that the user cannot perceive with his own senses. This makes AR technology suitable as a tool to help users' perception and interaction with the real world. Information displayed by virtual objects helps users carry out activities in the real world. AR technology can be applied to all senses, including hearing, touch and smell. Besides being used in fields such as healthcare, military, and manufacturing industries.[11]

Determining Qibla direction using an android application with AR technology began to appear in 2013, but began to be discussed in 2015. This android application for

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[8] Anisah, Budiwati, *Tongkat Istiwa', Global Positioning System (GPS) dan Google Earth untuk Menentukan Titik Koordinat Bumi dan Aplikasinya dalam Penentuan Arah Kiblat,* (Semarang: Jurnal AlAhkam Walisongo, Volume 26, Nomor 1, April 2016).

[9] Borko Furth, *Hand Book of Augmented Reality,* (Department of Computer and Electrical Engeneering. 2014), 1-356.

[10] Siddhant Goel dan Avdesh Bhardawaj, *A Critical Analysis of Augemented Reality Learning by Applicability of IT Tools*. International Journal of Information and Computation Technology,Vol. 4 No. 4, 2014, 425-430.

[11] Rochmad Gama Saputra, *Makalah Augmented Reality Sebagai Citra 3 Dimensi*. Departemen Ilmu Komputer Dan Elektronika Fakultas Matematika Dan Ilmu Pengetahuan Alam Universitas Gadjah Mada, Yogyakarta. 2016.

determining Qibla direction using AR technology utilizes the location of the Kaaba and the user's location to determine a direct route between the two points, such as the route in Google Maps. To use the Qibla direction guide with AR technology, users are required to activate the location feature (GPS) on their smartphone and activate the camera feature. If the smartphone supports AR technology, the user can see the Qibla direction in the form of a projection of a two-dimensional or three-dimensional object in the camera feature. To get the Qibla direction, the user only needs to move according to the Qibla direction shown.

One of application for determining Qibla direction with AR technology is the Miqat application: Prayer Times, Qiblah, and *Hilal* Visibility which was created by Samer Joudi, a geospatial technologist from the United Arab Emirates. The *Miqat* application is an application for determining the Qibla direction which is very popular in several countries, with more than 5,000,000 (one million) downloads. The *Miqat* application can be downloaded on Google's digital content service, namely the Google Play Store and web pages on the Internet. Qibla direction calculations in the *Miqat* application use the Vincenty method, which is a formula for calculating azimuth and the distance between two points on an ellipsoid surface. The Vincenty method has an accuracy value of 0.5 mm (0.020") on the Earth's ellipsoid. The Miqat application maps the results of calculating the Qibla direction using Google Maps to allow users to visually verify the Qibla with the help of things around them such as buildings and roads.

From the explanation above, determining the Qibla direction using an android application with AR technology is something new in society because AR technology is generally only known by information technology experts. With the *Miqat* application that utilizes AR technology, the general public can recognize and experience the sophistication of AR technology, especially for determining Qibla direction. However, the level of accuracy in determining the Qibla direction requires further research so that it can be utilized by the community with full responsibility.

B. Method

This study falls under the category of descriptive qualitative research (descriptive research) with a field research approach (field research), and it aims to learn more about the theory, procedures, calculations, and accuracy of the *Miqat* Android application study. The

primary data sources used are data from the Miqat application and interviews with Samer Joudi, while the secondary data used is literature related to determining Qibla direction and Augmented Reality technology. The method of data analysis carried out by researchers is to determine the Qibla direction using the 3D Qibla feature in the Miqat application which will then be compared with the determination of *Istiwa'aini* Qibla direction by Slamet Hambali to find out its accuracy with the location at the Central Java Grand Mosque (Masjid Agung Jawa Tengah).

C. Result and Discussion

C.1 Qibla Direction and Its Accuracy

Etymologically, the word Qibla comes from the Arabic language with the word قبلة. The word قبلة is one of the masdar forms of the verb قبل – يقبل – قبلة which means to face.[12] Then, the meaning is specific to a direction, where all people who establish prayer face him.[13] Qibla, which has a sense of direction, means synonymous with the words jihah and syatrah, which in Latin are known as azimuth. In the discourse of astronomy, azimuth is defined as the direction whose position is measured from the north point along the horizon circle in a clockwise direction.[14] In the Big Indonesian dictionary and Popular Scientific dictionary. Qibla is interpreted as a direction or destination.[15] There are those who interpret the Qibla as the direction or the cardinal points.[16] The purpose of this definition leads to the meaning of Qibla as the direction to the Kaaba in Mecca during prayer or the direction to the Kaaba in Mecca, it is in this direction that Muslims must face every prayer five times a day.[17] In the Qur'an the word Qibla has two meanings, namely direction and place.[18]

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[12] Ahmad Warson Munawir, *Al Munawir Kamus Arab-Indonesia*, (Surabaya: Pustaka Progressif, 1997), 1087-1088.

[13] Ahmad Mustafa al-Maraghi, *Terjemah Tafsir al-Maraghi, Juz II, Penerjemah: Anshori Umar Sitanggal*, (Semarang: CV. Toha Putra, 1993), 2.

[14] Moh. Murtadho, *Ilmu Falak Praktis*, (Malang: UIN-Malang Press, 2008), 123-124.

[15] Leonardo D. Marsam, *Kamus Praktis Bahasa Indonesia*, (Surabaya: Cv. Karya Utama, 1983), 145.

[16] W.J.S Poerwadarminta, Pusat Bahasa Departemen Pendidikan Nasional, *Kamus Umum Indonesia*, (Jakarta: Balai Pustaka,2006), 594

[17] Bumi Kurniawan, *Kamus Ilmiah Populer*, (Surabaya : CV. Citra Pelajar, t.th), 217.

[18] Moh. Murtadho, *Ilmu Falak* Praktis, 125.

According to thus terminology, the discussion about the Qibla is none other than talking about the direction to the Kaaba. Scholars' various definitions of Qibla direction, including:

a. The Ministry of Religion of the Republic of Indonesia defines a certain direction for Muslims to direct their faces in performing prayers.[19]
b. Abdul Aziz Dahlan and his friends define the Qibla as the building of the Kaaba or the direction that Muslims are aiming for in carrying out some of the worship.[20]
c. Harun Nasution and his friends in the Encyclopedia of Islamic Law define the Qibla as the direction to face when praying.[21]
d. Mochtar Effendy interprets the Qibla as the direction of prayer, the direction of the Kaaba in the city of Mecca.[22]

A person facing the Qibla should travel in the closest direction, according to some astronomers who link the idea of Qibla direction with the idea that the earth is a spherical world. This is based on the theory of a spherical earth where the implication between "facing" and "backward" is the same, the only difference is the distance traveled. The definition of Qibla direction which relates to the distance traveled can be seen in the formulation of several scholars, among others.[23]

a. Slamet Hambali interprets the Qibla direction as the direction towards the Kaaba (*Baitullah*) through the closest path and it is mandatory for every Muslim to face that direction when performing prayers anywhere in the world.[24]
b. Ahmad Izzuddin interprets the Qibla direction as the closest direction from a person to the Kaaba and every Muslim is obliged to face towards it when praying.[25]

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[19] Departemen Agama RI, *Ensiklopedia Islam*, (Jakarta : CV. Anda Utama, 1993), 629.

[20] Abdul Azis Dahlan, et al, *Ensiklopedi Hukum Islam*, (Jakarta: PT Ichtiar Baru Van Hoeve, Cet I, 1996), 944.

[21] Harun Nasution, et al, *Ensiklopedi Hukum Islam*, (Jakarta: Djambatan, 1992), 563.

[22] Mochtar Effendy, *Ensiklopedi Agama dan Filsafat, Volume 5,* (Palembang: Penerbit Universitas Sriwijaya, 2001), 49.

[23] Moh. Murtadho, *Ilmu Falak Praktis*,125.

[24] Slamet Hambali, *Ilmu Falak 1 (Penentuan Awal Waktu Shalat dan Arah Kiblat seluruh Dunia),* 167.

[25] Ahmad Izzuddin, *Ilmu Falak Praktis ; Metode Hisab-Rukyat Praktis dan Solusi Permasalahannya*, (Semarang: Pustaka Rizki Putra, 2012), 20

c. Muhyiddin Khazin the Qibla direction is the direction or the shortest distance along the great circle that passes through the city of Mecca (*Kaaba*) to the city in question, such as Jakarta with the direction closest to Mecca is the west direction oblique to the north.[26]

According to this explanation, it can be concluded that the definition of Qibla as the closest direction from a person to the Kaaba in Mecca is calculated along the great circle of the globe where facing that direction is an obligation for Muslims who pray. We can find the legal basis for facing the Qiblah in Q.S al-*Baqarah* [2] verse 144:

> "Indeed, We (often) see your face looking up to the sky, so indeed, We will turn you to the Qibla that you like. Turn your face towards the Masjidilharam. Every where you are, turn your face on him. And actually those people (Jews and Christians) who were given the Al-Kitab (Torah and Bible) do know that turning to the Grand Mosque is true from their Lord; and Allah is by no means unaware of what they do."

This verse instructs Muslims to face the Kaaba correctly when performing prayers, whether they are looking directly or indirectly. The command to face the Qibla is explicitly ordered with the text فول وجهك شطر المسجد الحرام. The word فول which means turn away is fi'il amar which means order. The command to turn away in this verse means to turn the face and limbs towards the Qibla. Then, in the *Sūrah* al-Baqarah [2]: 149 there is a directive to face the *Masjidil Haram* wherever the Prophet left and wherever he was accompanied by an affirmation that this provision was truly from Allah. Also accompanied by subtle threats so that there is no tendency to deviate from the truth. Allah repeats the command to face the Qibla once again, to explain that facing the Qibla is common (ordinary) in all times and places. Facing the *Masjidil Haram* is a common Shari'a at all times and places. Facing the Qibla (*Masjidil Haram*) is a truth that is in accordance with the wisdom and benefit that comes from Lord. Allah says in *Sūrah* al-Baqarah [2]: 150:

> "Wherever you come out, turn your face towards the Masjidil Haram. Wherever you are, turn your face in that direction so that there is no reason for anyone to oppose you, except for the wrongdoers. Do not be

[26] Muhyiddin, *Ilmu Falak Dalam Teori dan Praktik*, (Yogyakarta : Buana Pustaka, Cet ke-3, 2004), 48.

> afraid of them, but fear Me so that I may complete my favor on you and so that you may be guided."

Looking at these verses, the words فول وجهك شطرالمسجد الحرام is mentioned up to three times. According to Ibn Abbas as quoted by Ibn Kathir, this repetition serves as an affirmation of the importance of facing the Qibla (*ta'kid*). Meanwhile, according to Fakhruddin al-Razi as quoted by Ibnu Katsir, the repetition shows different functions. In *Sūrah* al-Baqarah [2]: 144, this expression is addressed to people who can see the Kaaba, whereas in *Sūrah* al-Baqarah [2]: 149, this expression is addressed to those who are outside the *Masjid al-Haram*. Meanwhile, in *Sūrah* al-Baqarah [2]: 150, this expression is addressed to people who are in distant lands.[27]

Al-Hafiz in *Fatḥ al-Bārī* explained that the change of Qibla was accepted by the Prophet during the midday prayers. The news spread throughout the city of Medina when it was time for Asr, and the news arrived at Quba (a village 3 miles away from Medina), was during the dawn prayer the next day. Ubbad bin Basyar from Bani Salamah, who conveyed it to the people of Quba. Ubbad told them that he had been praying with the Prophet facing the Kaaba, no longer facing the Baitul Maqdis. When people who were praying, heard what he said, they turned towards the Kaaba.[28]

At first, the Qibla was directed towards Baitul Maqdis or the Jerusalem Aqsa Mosque in Palestine. However, in 624 AD when the Prophet migrated to Medina, the Qibla direction moved towards the Kaaba in Mecca until now with the instructions of revelation from Allah SWT. Some scholars argue that the revelation of the Qibla shift was due to the dispute between the Prophet Muhammad in Medina.[29]

Ulama's have agreed on the Kaaba as the center of prayer for all Muslims in carrying out the obligatory prayers, but at the technical and administrative level facing the Qibla there are differences of opinion, especially in territorial areas far from the Kaaba. On the other hand, in areas that are so far away that the physical form of the

[27] Ibn Katsir, *Tafsir al-Qur'an al-'Azhim, Jilid I*, (Beirut: Dar al-Fikr, 1992), 243.
[28] Imam al-Hafiz Ahmad bin Ali bin Hajar al-Asqalani, *Fath al-Bari*, *Juz I*, (Beirut: Dar al-Fikr, t.t), 506.
[29] Ahmad Izzan dan Iman Saifullah. *Studi Ilmu Falak Cara Mudah Belajar Ilmu Falak*, (Banten: Pustaka Aulia Media, cet ke-1, 2013), 98.

Kaaba is not visible, the scholars still differ on the technicalities of facing the Qibla.[30] There are at least two versions of opinion among scholars, namely:

a. Opinions of al-Shāfi'ī and Hanbalī Scholars. According to them, what is obligatory is to go to the '*ainul Kaaba*. And for people who cannot see the Kaaba directly, then he must deliberately face the direction where the Kaaba is even though in essence he is facing his soul. So that the obligation is to face the direction of the Kaaba exactly and it is not enough to just face it.[31]

b. Opinion of Ḥanafī and Mālikī Scholars. According to both of them, what is obligatory is that *Jihah al-ka'bah* is sufficient, so for people who can witness the Kaaba directly, they must face the ainul Kaaba, if he is far from Mecca, it is enough to face him (not necessarily exactly). , so it's enough with his presumption that there is the Qibla.[32]

Based on human position on Earth, astronomy has the idea that one should face the direction of the Qibla. The Spherical Trigonometry formula is used to determine the Qibla direction since every point on the surface of the Earth is also on its sphere.[33] Nowadays, there are three major theories used to determine the azimuth or Qibla direction of a place on the earth's surface, namely the theory of navigation, the theory of spherical triangles, and the theory of geodesy. These theories are based on two references, namely the direction that refers to a line that has a constant direction, which is called a loxodrome, and the direction that refers to a line that has a direction that is not constant, which is called an orthodrome. Loxodrome is a directional reference used in navigation theory. The orthodrom is a directional reference used in the theory of trigonometry and geodesy theory. The difference between the theory of trigonometry and geodesy is that in the theory of trigonometry the paradigm used is that the earth is round like a ball (sphere) while in the theory of geodesy the paradigm used is that the earth is in the shape of an ellipse (ellipsoid). From a comparison of the

[30] Moh. Murtadho, *Ilmu Falak Praktis*, 132.

[31] Abdurrahman bin Muhammad Awwad Al-Jaziry, *Kitabul Fiqh Ala Madzahibil Arba'ah*, (Beirut: Dar Ihya At tyrats Al araby, 1699), 177.

[32] Muhammad Ali As Shabuni, *Tafsir Ayat Ahkam As Shabuni*, (Surabaya: Bina Ilmu, 1983), 82.

[33] Muhyiddin Khazin, *Ilmu Falak Dalam Teori dan Praktik*, (Yogyakarta : Buana Pustaka, Cet ke-3, 2004), 52.

calculations of the Qibla direction theory which refers to the orthodrom line (spherical trigonometry theory and geodesy theory) and the loxodrome line (navigation theory), the most precise and accurate theory in calculating the Qibla direction is to use the orthodrom line, namely the geodetic theory with the concept of shape Earth that is closer to the ellipsoid.[34]

Indonesia is geographically located between latitudes 6° N and 11° S and longitudes 95° E and 141° E. The range of Indonesian Qibla direction values varies from azimuth 290° to 296°. The smallest value, namely azimuth 290° 09', is in Merauke City (the capital of Merauke Regency, Papua). While the largest value, namely the azimuth of 293°33', is in the City of Manna (the capital of South Bengkulu Regency, Bengkulu). Thus, for all regions of Indonesia, the Qibla azimuth difference is 5°24'.[35]

Slamet Hambali in his individual research report divides the accuracy of Qibla direction measurements into 4 categories, namely:

a. Very accurate, when the results of measuring the Qibla direction succeed in obtaining the correct Qibla direction towards the Kaaba (Masjidil Haram).
b. Accurate, if the results of measuring the Qibla direction are different/differences do not meet Thomas Djamaluddin criteria who considers the deviation value of 0°42'46.43" is still in the accurate category.
c. It is inaccurate, when the results of measuring the Qibla direction are deviated between 0°42'46.43" to 22°30', this is because the deviation of the Qibla direction for Indonesian territory which exceeds the value of 22°30' will tend to head straight west.
d. It is inaccurate, if the results of measuring the Qibla direction are deviated above 22°30', this is because the deviation is above 22°30', the Qibla direction for Indonesian territory will tend to lean south from the west point.

Thomas Djamaluddin has the opinion that the Qibla direction deviation is not from the deviation from the Kaaba, but is measured at our position point, because the farther from the Kaaba, the more difficult it is for us to make the direction accurate.

[34] Ahmad Izzuddin, *Kajian Terhadap MetodeMetode Penentuan Arah Kiblat dan Akurasinya*, 145-146.
[35] Marufin Sudibyo, *Sang Nabi Pun Berputar; Arah Kiblat dan Tata Cara Pengkurannya*, 138-139.

Qibla direction is the direction facing, so the deviation that is allowed is a deviation that does not significantly change the direction by naked eye, including the line of rows of mosques or prayer rooms. For this reason, according to Thomas Djamaluddin, a deviation of approximately 2 degrees is still within the tolerance limit.[36]

C.2 Augmented Reality Concept and How It Works

Augmented reality virtual objects into a three-dimensional real environment and then projects these virtual objects in real time.[37] According to Soha Maad, augmented reality is a technology for creating and integrating virtual objects into the real world. Ronald T. Azuma defines augmented reality (AR) as a combination of real and virtual objects in a real environment, running interactively in real time, and there is integration between objects in three dimensions, namely virtual objects integrated in the real world.[38]

AR is a variation of Virtual Environments (VE), or better known as Virtual Reality (VR). VR technology makes users join in a virtual environment as a whole. When joined in the environment, the user cannot see the real environment around him. In contrast, AR allows the user to view the real environment, with virtual objects added to or merged with the real environment. Unlike VR which completely replaces the real environment, AR simply adds or complements the real environment.[39]

Merging real and virtual objects is possible with appropriate display technologies, interactivity is possible through certain input devices, and good integration requires effective tracking. In addition to adding virtual objects in a real environment, AR also has the potential to remove existing objects. Adding a virtual image layer is possible to remove or hide the real environment from the user's view. For example, to hide a table in a real environment, it is necessary to draw a layer of representation of empty walls

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[36] Thomas Djamaluddin, Arah Kiblat Tidak Berubah, https://tdjamluddin.wordpress.com/2010/05/25/arah-kiblat-tidak-berubah/, Accessed on November 21, 2022.

[37] Julie A. Jacko, *Handbook of Research on Ubiquitous Computing Technology for Real Time Enterprises*. (CRC Press, 2003). 459.

[38] *Ronald T. Azuma, "A Survey of Augmented Reality". Presence: Teleoperators and Virtual Environments. Vol. 6 No. 4 Agustus 1997*, 355–385.

[39] Ari Budiyanto, *Teknologi Augmented Reality Dan Face Tracking Sebagai Media Simulasi Kacamata Virtual (Studi Kasus : Optik Pelita Yogyakarta),* (Yogyakarta : Naskah Publikasi Jurusan Teknik Informatika Sekolah Tinggi Manajemen Informatika Dan Komputer Amikom Yogyakarta, 2011), 2.

and floors placed over an image of the real table, thereby covering the real table from the user's view.

Milgram and Kishino formulated a framework for the possibility of merging and fusing the real and virtual worlds into a virtuality continuum.[40] The far left side is the real environment which contains only real objects, and the far right side is the virtual environment which contains virtual objects. In augmented reality, which is closer to the left, the environment is real and objects are virtual, while in augmented virtuality, which is closer to the right, the environment is virtual and objects are real. Augmented reality and augmented virtuality are combined into mixed reality or mixed reality. AR can be applied to all senses, including hearing, touch, and smell. Apart from being used in fields such as healthcare, the military, the manufacturing industry, augmented reality has also been applied to devices that are used by many people, such as mobile phones.

AR technology is a technology that is not widely known. The main goal of AR is to present the sensation of virtual objects that are present in the real world. To achieve this is by combining VR devices into the real world. Meanwhile, VR is no longer possible. Therefore, AR is the most effective technology if virtual elements are added to it. How Augmented Reality Technology Works is by making markers/markers as an important component in managing Augmented Reality (AR) applications. Marker functions to translate objects that will be displayed on the display. The marker will be recognized by a webcam camera or smartphone camera as a form of a real object symbol that will become an intermediary between the device and the 3D model of each Augmented Reality (AR) object.[41]

There are three methods of using markers, namely:

a. Marker Based Augmented Reality

This marker is usually a square black and white illustration with a thick black border and a white background, in this study using a marker that contains patterns

[40] *Julie A. Jacko, Handbook of Research on Ubiquitous Computing Technology for Real Time Enterprises. (CRC Press, 2003).* p. 258–259.

[41] Kurniawan Teguh Martono dan Rinta Kridalukmana, *Mobile Augmented Reality Jurusan Sistem Komputer Universitas Diponegoro Berbasis Android (MARSISKOM)*, (Semarang : Jurnal Sistem Komputer Universitas Diponegoro Vol.4 No. 1, Mei 2014), 17-18.

from animal images. On a computer you can recognize the position and orientation of the marker object and create a 3D virtual world, namely the point (0,0,0) and the axis consisting of X, Y and Z. Marker Based Tracking has been developed for a long time starting in the 1980s and started developed in the use of Augmented Reality.[42]

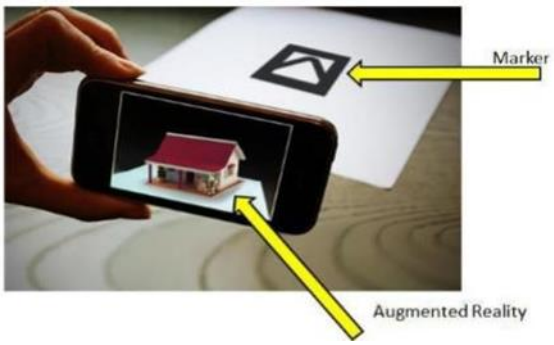

Figure 1. Marker Based Augmented Reality

b. Markerless Augmented Reality

Markerless Tracking in Augmented Reality is a method of Augmented Reality without using frame markers as detected objects. With this type of marker, the use of markers as tracking objects that have been taking up space, will be replaced with images, or any surfaces filled with writing, logos so that they can directly involve the object being tracked so that it can look alive and well. interactive, also no longer reduces space efficiency with markers. On progress. there are three technologies in Markerless Based Tracking such as Face Tracking, 3D Object Tracking, and Motion Tracking.[43]

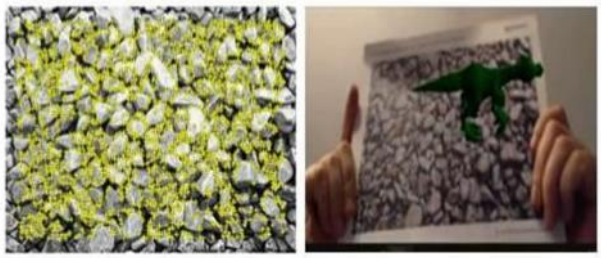

Figure 2. Markerless Augmented Reality

c. GPS Based Tracking

[42] Marco Karim Solin, *Implementasi Augmented Reality Pada Perancangan Sistem Katalog Digiprocreative Berbasis Android,* (Sumatera Utara: Skripsi Program Studi Ilmu Komputer, Fakultas Komputer dan Teknologi Informasi, Universitas Sumatera Utara, 2014), 21-22.

[43] Yoze Rizki, *Markerless Augmented Reality Pada Perangkat Android*, (Surabaya : Proceeding Seminar Tugas Akhir Jurusan Teknik Elektro, Fakultas Teknologi Industri, Institut Teknologi Surabaya, 2012), 2.

GPS Based Tracking is an augmented reality technology that works by utilizing the GPS and Compass features on smartphones. The application will retrieve data from the GPS and compass then display the shape of the desired direction in real time, there are even some applications that display it in 3D.[44]

Figure 3. GPS Based Tracking

The working principle of Augmented Reality (AR) in processing data and displaying 3D images is as follows:

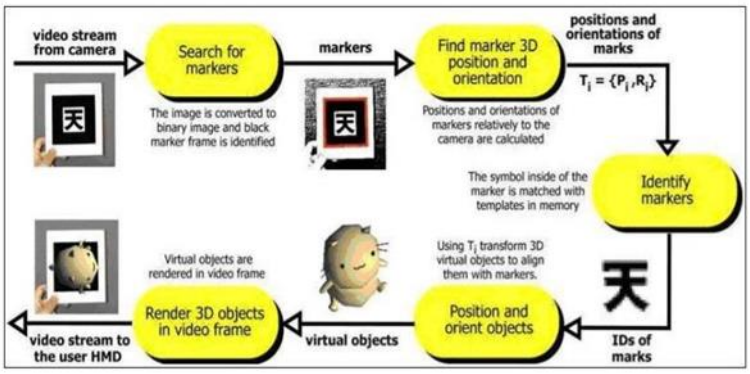

Figure 4. The working principle of Augmented Reality

a. The camera captures data from markers in the real world and sends the information to the computer.
b. Software on the computer will track the box shape of the marker and detect how many video frames it contains.
c. When the box has been found, the software uses mathematical calculations to calculate the position of the camera relative to the black box on the marker.

[44] Monster AR, Mengenal Jenis-Jenis Dari Teknlogi Augmented Reality, diakses dari https://www.monsterar.net/2017/08/08/mengenal-jenis-augmented-reality/, Accessed on Juli 16, 2019.

d. After being calculated, the graphical model will appear in the same position and within the scope of the black box, then displayed on the screen to see the graphics in the real world.

The Miqat app uses augmented reality to provide information on prayer times, the direction of the Qibla, and the visibility of the new moon. The Markerless Augmented Reality technique, which integrates augmented reality technology with GPS in real time, is used by the Miqat application.

C.3 Samer Joudi Biography

Samer Joudi is a Geospatial Technology Specialist or Geographic Information System who was born in Syria in 1970. Samer Joudi graduated with a Bachelor of Architecture in 1994 at the University of Aleppo, Syria. Then Samer Joudi continued his studies from 2013 to 2015 at the University of Strathclyde, UK and earned a Master of Business Administration (MBA) degree with Distinction. In 2018, Samer Joudi learned about Artificial Intelligence: Implications for Business Strategy in Executive Education at the Massachusetts Institute of Technology, United States.[45] Below is the employment history of Samer Joudi:

a. Engineer at the General Organization for Land Development in Aleppo, Syria in 1955.
b. Worked part time as a CAD (Computer Aided Design) / GIS (Geographic Information System) Engineer at the Office of Informatics Services (Canadian-Syrian Company), Aleppo, Syria from 1997 to 1999.
c. Specialist at Deutsche Gesellschaft for Technische Zusammenarbeit (GTZ) GmbH. Aleppo, Syria in 1998 to 1999.
d. Manager and Developer at Amana Zamil Steel Building Contractors, Dubai, United Arab Emirates in 1999 to 2000
e. Road Department Analyst - Municipality of Dubai, United Arab Emirates in 2000 to 2005.
f. Chief Analyst of Roads and Transport Authority, Dubai, United Arab Emirates in 2005 to 2010.

[45] Email interview with Joudi at March 23, 2019

g. GPC-GIS (The Geographic Planning Collaborative - Global Information Solutions) senior consultant at Abu Dabhi Information and Systems Center (ADSIC), Abu Dhabi, United Arab Emirates in 2010 to 2017.
h. Manager of Artificial Intelligence at Roads and Transport Authority, Dubai, United Arab Emirates in 2017 to 2018.
i. Chief Specialist of Roads and Transport Authority, Dubai, United Arab Emirates in 2018 to present.[46]

Samer Joudi has received several awards in the field of information technology, such as:

a. Award from the United Nations (UN) Program for CAD, GIS & GPS Magazine in 2005 as "Best eContent in the United Arab Emirates".
b. Award from United Arab Emirates Web for CAD, GIS & GPS Magazine in 2006 as "Best Website in United Arab Emirates".
c. Award from Pan Arab Web for CAD, GIS & GPS Magazine in 2007 as "Best Website in Arab World".[47]

Samer Joudi has published his book entitled "Mastering Coordinates: The Complete Guide for GIS Professionals" or if translated means Mastering Coordinates: The Complete Guide for GIS (Geographic Information System) Professionals. In addition, Samer has also translated several books, such as Dubai Discovered, Dubai Street Atlas Explorer, Dubai: Tomorrow's City Today, and Sharjah's Architectural Splendor. Sharjah Architecture). Another achievement of Samer Joudi is an Android application called "Miqat: Prayer Times, Qiblah, and Hilal Visibility" which can help someone find out prayer times, Qibla direction, and the visibility of the new moon by providing various interesting features and Augmented Reality technology.[48]

[46] Email interview with Joudi at March 23, 2019
[47] Email interview with Joudi at March 23, 2019.
[48] Email interview with Joudi at March 23, 2019

C.4 The Miqat Application and the Results of Determining the Qibla Direction

Figure 5. Miqat Application Logo

The Miqat Application: Prayer Times, Qiblah, and Hilal Visibility or abbreviated as the Miqat Application, is an android application that focuses on determining the Qibla direction using augmented reality or AR technology. The background for creating this application was because the developer found that there were many problems understanding the coordinate system. Examples include incompatibility problems between data on images, maps, or satellite imagery. The misunderstanding was caused by the map itself. A very popular map uses a cylindrical projection which distorts the map and makes people think that the direction between two locations is just a straight line between them. But this is completely wrong, the cylindrical projection distorts the north and south of the world so that the earth is printed on the rectangle, but the top and bottom edges of the rectangle are just the true north and south poles (dots) being lines along the equator.

Using an azimuth projection, which centers the target on the projection, we may determine the direction to any location by simply drawing a straight line from our location to the desired location. To calculate the direction between two locations, you can use the Vincenty formula which is very accurate because it uses the concept of an ellipsoidal earth. The Vincenty formula will show how many degrees a person must turn to the right or left from true north to face another location.

To determine the Qibla Direction using the AR Qibla Finder application, several requirements are required, including:

a. Give permission to This app to access Location (GPS) and Camera on android Smartphone. Location access permission is required so that this application can process Qibla direction data, prayer times, and the new moon visibility related to

latitude, longitude, and altitude coordinates of the user's place. To get accurate data, users can set GPS to high accuracy in phone settings. In addition, to get high GPS accuracy, a good and stable internet connection is needed.

b. While camera access permission is required so that this application can properly display Qibla's 3D features which have augmented reality technology.

c. Smartphones should have Magnetic, Gyroscope, 3D Orientation, and Magnetometer sensors. With the availability of a magnetic sensor, this application can show the Qibla line that connects the user's coordinates to the coordinates of the Kaaba according to the cardinal directions on the Qibla Map feature. In addition, magnetic sensors are also used to show the Qibla line in the 3D Image of the Kaaba in the 3D Qibla feature. If the smartphone is not accompanied by a compass at all (such as the Samsung J7), then it is sufficient to rotate the device itself and align the map with buildings and streets to find the correct Qibla. To obtain high accuracy, users are advised to calibrate the smartphone's compass first. Gyroscope sensor is useful for detecting the movement of the smartphone. In this application, the Gyroscope sensor is useful for detecting up, down, left, right, forward, backward, rotational movements, and so on. The 3D Orientation sensor is useful for knowing the orientation of the cellphone and detecting the position of the smartphone whether it is in landscape or portrait mode. While the Magnetometer sensor is useful for knowing which objects emit strong, weak, or not magnetic fields.[49]

d. Smartphones support the Open GL ES application, at least version 2.0 to the latest. Open GL stands for Open Graphics Library, is a platform-independent Application Programming Interface (API) that allows one to create hardware-accelerated 3D graphics. OpenGL ES, short for OpenGL for Embedded Systems, is part of the API. OpenGL ES is a low level API. In other words, it doesn't offer any methods that let you create or manipulate 3D objects on the fly. Instead, when working with it, you are expected to manually manage tasks

[49] Inpomu, *Berbagai Macam Sensor Dan Fungsinya*, Accessed from https://inpomu.blogspot.com/2016/01/berbagai-macam-sensor-dan- fungsinya.html, on July 20, 2019.

such as creating individual vertices and faces of 3D objects, calculating various 3D transformations, and creating various types of shaders.[50]

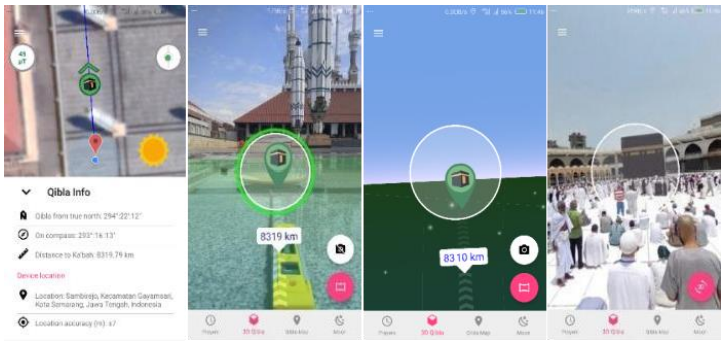

Figure 6. Display of the Qibla Direction Feature on the Miqat Application

The Qibla direction in the Miqat application uses the Vincenty formula which has high accuracy to determine the Qibla direction based on the ellipsoid shape of the Earth. The augmented reality marker in this application is placed at the coordinates of the Kaaba that are used in the application, namely 21°25'21.15" S and 39°49'34.10" E. There are 2 Qibla direction features in this application, namely Qibla Map and 3D Qibla (3 Dimensions).

In determining the Qibla direction, this application uses the Vincenty formula which is the calculation of the correct direction for the term ellipsoid of the earth. In geodesy, the determination of the point is expressed by coordinates that refer to the coordinate system of the World Geodetic System 1984 (WGS 84). In the WGS 84 coordinate system, which is a right-handed Cartesian coordinate system, the reference ellipsoid used is the WGS 84 geocentric ellipsoid which is defined by four main parameters, namely; long axis (a) = 6,378,137.0 m, flattening (1/f) = 298.257223563, Earth's angular velocity (ω) = 7,292,115.0 x 10-11 rad s^{-1} and Earth's gravitational constant (including atmospheric mass)) (GM) = 3,986,004.418 x 108 m^3 s^{-2}.[51]

In the Vincenty formula there are two main geodetic questions, namely: First, determining the coordinates of a point from another point whose coordinates are known based on the distance and azimuth from that other point to that point (direct geodetic problem), Second, determining the distance and azimuth of two points the

[50] Code Tutsplus, *Tutorial How To Use OpenGL ES In Android Apps,* diakses dari https:// code.tutsplus.com/id/tutorials/how-to-use-opengl-es-in- android-apps--cms-28464, Accessed on Juli20, 2019

[51] Hasanuddin Z. Abidin, *Geodesi Satelit*, (Jakarta: Pradnya Paramita, 2001), 47.

coordinates are known (inverse geodetic problem). 43 From the two points above, the theory of the inverse geodetic problem can be used to calculate the Qibla azimuth of a place and its distance from the Kaaba. Determining Qibla direction using an android application with augmented reality technology is a new method that is quite easy and practical. Users only need to activate the data network and allow access to the smartphone's location and camera, then run the Miqat application by Samer Joudi, select the Qibla Map feature, if the data is correct then select the 3D Qibla feature and point the smartphone towards the Qibla line indicated by the application.

In determining the Qibla direction in the Miqat application, the user's location data will be processed through the calculation of the Vincenty formula in the Microsoft Office Excel program whose results will be displayed on the Qibla Map feature with rounded values to degrees. The Vincenty formula is an accurate calculation of direction because it terms the earth with an ellipsoid shape. The term ellipsoidal earth assumes that the distance from the center of the earth to the equator is not the same as the distance from the center of the earth to the poles. According to the 1984 World Geodetic System (WGS), the equatorial radius (a) is 6778137 meters, while the polar radius (b) is 6356752.3 meters. This of course affects the flattening or flatness of the earth (f) which is calculated by the Vincenty formula. This is the fundamental difference between the Vincenty formula and the Qibla direction formula that has been practiced so far.

The Qibla direction formula so far always assumes the earth is a perfect sphere without regard to the flatness of the earth so that the value of f = 0. Meanwhile, in the Vincenty formula which takes into account the flatness of the earth, the f value has a certain value. If in the Vincenty formula the value f is given a value of 0 then the resulting Qibla azimuth will be the same as Qibla azimuth which assumes the earth is a ball. If the value of f is getting bigger, the difference in value will also be getting bigger linearly or proportionally.[52]

Determining the Qibla direction using the Miqat application has several weaknesses, including the user being required to pay attention to the location to be

[52] Rinto Anugraha, Arah Kiblat Dengan Metode Vincenty, accessed at https://rintoanugraha.staff.ugm.ac. id/arah-kiblat-dengan-metode-vincenty/ on August 18, 2019.

measured and the data displayed by the application. Users are advised to find a field area and get stable internet access, because GPS can accurately show the user's location data if they get a strong satellite signal. Satellite signals are the main thing to get this data, the use of the Miqat application such as when in a room, tunnel, a place with lots of trees or buildings is usually difficult to get a satellite signal, so the location shown in the Qibla Map feature is less accurate. If the location shown in the Qibla Map feature is inaccurate, then the direction shown by the Qibla line on the Qibla 3D feature will also be inaccurate.

In addition, the user must pay attention to the condition of the Qibla direction testing location which will be determined carefully. Keep your smartphone away from locations with high magnetic fields. Locations that have a high magnetic field will certainly interfere with the Qibla direction testing process because the direction shown by the smartphone still uses a magnetic compass sensor which is prone to interference from the surrounding magnetic field. At the time of measurement, position the smartphone vertically or perpendicularly, and orient the smartphone according to the Qibla line image shown in the Qibla 3D feature. This is because if the smartphone does not stand straight and fixed, then the Qibla line image shown will deviate from the Qibla direction shown by augmented reality technology.

Calculation of the Qibla direction on the Qibla Map feature that uses the Vincenty formula produces an accurate Qibla direction because it has a difference of about 7 minutes from the calculation of the Qibla direction which assumes the earth is a ball. With that difference, determining the Qibla direction on the Miqat application can also be used to determine an accurate Qibla direction. However, in practice determining the Qibla direction using the Miqat application which has augmented reality technology on the 3D Qibla feature results in an inaccurate Qibla direction. This is because the Qibla direction shown still refers to the magnetic compass Qibla direction from the From the results of calculations using the Vincenty formula that the author did, the Qibla distance was 8319.79 km and the Qibla azimuth of the Great Mosque of Central Java was 294°22'11.83" UTSB. The results of this calculation are accurate because they differ by about 7 minutes from the azimuth of the Qibla direction of the Great Mosque of Central Java. I conducted a test for determining the

Qibla direction using an android application with augmented reality technology on the Miqat application which would be compared with the results of measuring the Qibla direction using the Istiwa'aini tool by Slamet Hambali. This is because the *Istiwa'aini* measurement results are fairly accurate compared to other methods of determining the Qibla direction. So that the *Istiwa'aini* method can be used to measure the accuracy of determining the Qibla direction in the Miqat application that uses the Vincenty formula and is supported by Augemented Reality technology. Smartphone, so that direction cannot show the actual direction.

In this test, a test instrument is needed in the form of a smartphone that meets the requirements needed in the Miqat application. These requirements are the availability of GPS sensors, Compass, Gyroscope, 3D Orientation, and Magnetometer, and supported by the Open GL ES application, at least version 2.0. Therefore, researchers use the ZTE Nubia M2 smartphone with the following specifications:

Table 1. Smartphone ZTE Nubia M2 Specification

Network	**SIM**	**GSM, CDMA, HSPA, 4G**
Platform	OS	Android 6 (*Marshmallow*); Nubia UI 4
	Chipset	Qualcomm MSM8953 Snapdragon 625 (14 nm)
	CPU	Octa-core 2.0 GHz Cortex-A53
	GPU	Adreno 506
Camera	Main Camera	13 MP, f/2.2, 1/2.9", 1.*25µm*, AF dan 2 MP, *depth sensor*
		Dual-LED *dual-tone* flash, HDR, Panorama
		2160p@30fps, 1080p@30fps
		16 MP, f/2.0 , 1080p@30fps
Fiture	WLAN	Wi-Fi 802.11 b/g/n/ac, *dual-band*, Wi-Fi *Direct*, Hotspot
	Bluetooth	4.1, A2DP, LE
	GPS	A-GPS, GLONASS, BDS
	Sensor	*Fingerprint* (*front-mounted*), *Accelerometer*, *Light*, *Orientation*, *Proximity*, *Gyroscope*, *Sound*, dan *Magnetic Sensor*
	USB	Type-C 1.0 *reversible connector*, USB *On-The-Go*

For the research location, the researcher used the location of the Central Java Grand Mosque (MAJT), this is because the Qibla direction has been tested and proven to be accurate. The test location that the researchers carried out was the easternmost area south of the electric umbrella (Shaf Putri), precisely at coordinates 110o26'45.04' East Longitude (BT) and - 6o59'2.06" South Latitude (LS). The following are the results of the accuracy test that the researchers got from the five tests, including:

Table 2. Accuracy Test Results

Number	Result	Category
1	The Qibla direction on the Miqat application deviates 1o from the Istiwa'aini Qibla direction	Inaccurate
2	The Qibla direction in the Miqat application is the same as Istiwa'aini Qibla direction	Very Accurate
3	The Qibla direction on the Miqat app is off the mark 0.5o from the Qibla direction of Istiwa'aini	Accurate
4	The Qibla direction on the Miqat application deviates 1o from the Istiwa'aini Qibla direction	Inaccurate
5	The Qibla direction on the Miqat application deviates 1o from the Istiwa'aini Qibla direction	Inaccurate

Among the five tests performed at various times and days, from July 17 to July 20 2019, one Qibla direction was obtained which was very accurate, one Qibla direction was accurate and three directions were inaccurate, with evidence as found in the first test. up to fifth. So it can be concluded that the results of determining the Qibla direction using the android application with Augmented Reality technology in the Miqat Karya Samer Joudi application are categorized as inaccurate according to the level of accuracy of Slamet Hambali, but are still within tolerance limits according to the level of accuracy of Thomas Djamaluddin. The accuracy of the Qibla direction of the Miqat application differs from 0o to 1o from the Qibla direction measured by *Istiwa'aini*.

D. Conclusion

Based on the discussion above, the authors can conclude several things as answers to the main issues, namely: Determining the Qibla direction using an Android application with Augmented Reality technology in the Miqat application by Samer Joudi is relatively easy and practical. The results of calculating the Qibla direction are accurate when in use it pays attention to the requirements needed by the application, location data, and the measurement process. Second, the determination of the Qibla direction using an android application with Augmented Reality technology on the Miqat application by Samer Joudi is less accurate according to the accuracy level of Slamet Hambali but is still within tolerance

limits according to the accuracy level of Thomas Djamaluddin. The level of accuracy is different from 0o to 1o from the Qibla direction from the measurement of Istiwa'aini by Slamet Hambali.

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