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THEORETICAL STUDY OF THE USE OF THE POLARIS STAR AS A REFERENCE FOR THE NORTH POINT IN DETERMINING THE QIBLA DIRECTION

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Abstract

The accuracy of determining the north point is a very important matter in determining the Qibla direction. Finding the north using a compass, especially in buildings, is not encouraged so that an alternative method is needed. Apart from using a compass and istiwa stick (gnomon), Polaris can also be used to reference the north, but it is not popular because of its limited appearance, which is only easily observed in areas which located above latitude 10o N. This study aims to examine theoretically the accuracy of Polaris as a reference for the north point in determining the Qibla direction. This research belongs to library research using secondary data. The data were obtained from various sources such as Stellarium software and various relevant articles. Based on this research, it is concluded that in the region near the equator (less than latitude 10o N), Polaris is difficult to observe because it is very low above the horizon. Thus, for the sake of determining the Qibla direction, the results are inaccurate. Whereas in regions that are located far north from the equator (at latitude above 10o N) the north point can be determined easily because Polaris can be observed quite high. Thus, its use in determining the Qibla direction is classified as accurate.

Keywords: *Polaris; north; Qibla direction*

Abstrak

Akurasi arah utara merupakan perkara yang sangat penting dalam penentuan arah kiblat. Penentuan arah utara menggunakan kompas, terutama di dalam bangunan termasuk cara yang tidak digalakkan sehingga diperlukan metode alternatif. Selain menggunakan kompas dan tongkat istiwa, bintang Polaris juga dapat digunakan untuk acuan arah utara, akan tetapi tidak populer digunakan dikarenakan keterbatasan kenampakannya yaitu hanya mudah diamati di wilayah di atas 10o lintang utara. Penelitian ini bertujuan untuk mengkaji akurasi bintang Polaris sebagai acuan titik utara dalam penentuan arah kiblat. Penelitian ini merupakan jenis penelitian kepustakaan (library research) dengan memanfaatkan data sekunder (secondary data). Datanya berupa kenampakan bintang Polaris yang diperoleh dari berbagai sumber seperti software Stellarium dan berbagai artikel yang relevan. Berdasarkan penelitian ini, disimpulkan bahwa di wilayah dekat ekuator (kurang dari 10o lintang utara), bintang Polaris sulit terlihat karena letaknya sangat rendah di atas horizon. Dengan demikian, untuk kepentingan penentuan arah kiblat, hasilnya tidak akurat. Sedangkan di wilayah yang terletak jauh di sebelah utara ekuator (di atas 10o lintang utara) arah utara dapat ditentukan dengan mudah

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http://dx.doi.org/10.22373/jiif.v22i1.9411

karena bintang Polaris dapat terlihat cukup tinggi. Dengan demikian, penggunaannya dalam penentuan arah kiblat tergolong akurat.

Kata kunci: *Polaris; Utara; Arah Kiblat*

مستخلص

دقة اتجاه الشمال مهمة جدا في تحديد اتجاه القبلة. تحديد اتجاه الشمال باستخدام البوصلة، خاصة داخل المباني، طريقة لا يتم تشجيعها بحيث تكون هناك حاجة إلى طرق بديلة. بالإضافة إلى استخدام البوصلة *والعصا الخاصة/ العصا الإستواء*، يمكن أيضًا استخدام نجم القطبي/ بولاريس كمرجع لاتجاه الشمال، ولكن لا يتم استخدامه بشكل شائع نظرًا لمظهره المحدود، والذي يمكن ملاحظته بسهولة فقط في المناطق التي تزيد عن 10 درجات شمال خط العرض. تهدف هذه الدراسة إلى فحص دقة نجم القطبي/ بولاريس كمرجع لنقطة الشمال في تحديد اتجاه القبلة. هذا البحث هو نوع من البحث المكتبي باستخدام البيانات الثانوية. البيانات في شكل ظهور نجم القطبي/ بولاريس تم الحصول عليها من مصادر مختلفة مثل برنامج ستيللاريوم والعديد من المقالات المنسبات بالبحث. بناءً على هذا البحث، استنتج أنه في المنطقة القريبة من خط الاستواء (أقل من 10 درجات شمالًا)، يصعب رؤية النجم القطبي/ بولاريس لأنه منخفض جدًا فوق الأفق. وبالتالي، لأغراض تحديد اتجاه القبلة ، فإن النتائج ليست دقيقة. وفي الوقت نفسه، في المناطق البعيدة شمال خط الاستواء (فوق خط عرض 10 درجات شمالًا) يمكن تحديد الاتجاه الشمالي بسهولة لأن النجم القطبي/ بولاريس يمكن رؤيته بشكل واضيح لارتفاعه. وبالتالي، فإن استخدامه في تحديد اتجاه القبلة دقيق تمامًا.

الكلمات الرئيسيّة: القطبي/ بولاريس؛ اتجاه القبلة؛

A. INTRODUCTION

Muslims have agreed that facing the Qibla in accordance with their entire abilities and efforts is a valid condition of prayer [1]. This has been exemplified by Prophet Muhmmad and told in a hadith narrated by Bukhari that the Prophet when he was in a corner of the mosque ordered a man who wanted to pray to face the Qibla, after completing his ablution [2]. Muslim scholars also agree that facing the Qibla must be with all their abilities and precisely, not just facing it carelessly. The Syafi'iyah and Hanabilah scholars state that the obligation to face the Qibla does not work unless it is facing the *'ain* (the building) of the Ka'bah. It means that this

[1] Sayful Mujab, "KIBLAT DALAM PERSPEKTIF MADZHAB- MADZHAB FIQH," *YUDISIA : Jurnal Pemikiran Hukum Dan Hukum Islam* 5, no. 2 (January 20, 2016), https://doi.org/10.21043/yudisia.v5i2.709.

[2] Muslim Muslim, "Sahih Muslim 397b - The Book of Prayers - كتاب الصلاة - Sunnah.Com - Sayings and Teachings of Prophet Muhammad (لى الله عليه و سلم)," 2021, https://sunnah.com/muslim:397b.

duty must be performed right up to the Ka'ba [3]. Thus, in order to fulfill the validity of prayer services and increase specialization, the correct direction to the *'ain* of the Ka'ba must be pursued by increasing the accuracy of north direction (point).

Accuracy in determining the north point, whether indicated by a compass, stick (gnomon), or celestial body is a very important matter in determining the Qibla direction namely for method that using a calculation approach. This is because the formulas in calculating the Qibla direction such as spherical trigonometry and the Vincenty formula always use the north point as reference. Apart from the interests of the Qibla direction, north point is also indispensable during the initial preparations for telescope operation. For example in the use of telescopes with equatorial mounting mode for observation of celestial objects [4]. In astronomy and geodesy, the direction of a place or celestial body seen from the observer's location is usually known as azimuth (*as-samtu*) which is measured from north point to east along the horizon circle [5]. That is why, the provisions of the north point are quite important in the study of astronomy and geodesy.

One of the methods of determining the north point that is often used for the purposes of determining the Qibla direction until now is using a compass, the result of which still requires magnetic declination correction [6]. This correction is necessary because the compass needle is pointing inappropriately to geographic north (north point and also known as true north). Determination of north point using a compass, especially inside buildings, is one way that is not encouraged [7] so an alternative method is needed. In addition to a compass, the direction of north (and south) can also be determined using the stick by making concentrated circular patterns. In addition to using a compass and stick, Polaris can also be used to reference north because it is directly above the north pole and is more accurate than a compass [8].

Since ancient times, Polaris has been used as a weather vane. This star is part of the constellation Ursa Minor (Little Dipper). Near this constellation, there is also the Ursa Major (Big Dipper) constellation or also known as *banat naash al-kubra*. Two stars from the

[3] Slamet Hambali, *Ilmu Falak: Arah Kiblat Setiap Saat* (Yogyakarta: Pustaka Ilmu, 2013).

[4] Will Gater, "British Astronomical Association | Supporting Amateur Astronomers since 1890," January 18, 2020, https://britastro.org/journal_item/7108.

[5] Muhyiddin Khazin, *Ilmu Falak: Dalam Teori Dan Praktik*, III (Yogyakarta: Buana Pustaka, 2004).

[6] Sulaiman Suri, "Pengukuran Arah Kiblat," Kantor Wilayah Kementerian Agama Provinsi Bengkulu, 2011, https://bengkulu.kemenag.go.id/artikel/8695-pengukuran-arah-kiblat.

[7] Norhana Arsad et al., "Sistem Penentuan Arah Utara Menggunakan Mems Giroskop" *Jurnal Falak* 4, no. 1 (2018): 145–62.

[8] Joe Rao, "The North Star: Polaris," Space.com, 2017, https://www.space.com/15567-north-star-polaris.html.

constellation Ursa Major (α-β Ursa Major), if a straight line is drawn approximately five times the distance of these two stars, it will directly target Polaris. For regions at the equator, Polaris is certainly hard to observe. However, the constellation Ursa Mayor can still be seen most of the year, especially in northern hemisphere countries that are located in high latitudes. So, by drawing a straight line in a multiple of five times the distance between these two stars, the direction of true north can be estimated [9].

The use of Polaris position for determining the Qibla direction is not popularly studied, both in Indonesia and throughout the world. For example, the research conducted by Asmuni et.al. (2020) entitled *The True North Urgency of the Earth in Determining the Direction of the Qibla According to Fiqh and Falak Science* does not discuss Polaris as a reference for north, but a compass.[10] As is known, the compass has a weakness in its use that is easily influenced by magnetic objects around it. Likewise, the subject of Qibla direction discussed in astronomy books at the Islamic Religious College, which can almost be said to have not discussed Polaris explicitly in determining the direction of north.

This research belongs to library research using secondary data. The data are in the form of the appearance of the Polaris star that was observed through the online Stellarium software and from various online articles on observations. This research is also included in qualitative research, namely research that the data are not in the form of numbers, but in the form of words and descriptions [11]. The research applied a scientific approach, which examines scientific problems which are then connected with the problem of determining the Qibla direction. This applies a descriptive analytical approach in analysis, which seeks to provide a critical analysis of the use of Polaris in determining the Qibla direction. The result of the analysis is the accuracy of Polaris as a reference for north point in determining the Qibla direction.

[9] Bruce McClure, "Polaris Is the North Star | Astronomy Essentials | EarthSky," 2019, https://earthsky.org/brightest-stars/polaris-the-present-day-north-star.

[10] Asmuni Asmuni, Hasan Matsum, and Imamul Muttaqin, "The True North Urgency of the Earth in Determining the Direction of the Qibla According to Fiqh and Falak Science," *Budapest International Research and Critics Institute (BIRCI-Journal): Humanities and Social Sciences* 3, no. 4 (November 6, 2020): 3353–58, https://doi.org/10.33258/birci.v3i4.1369.

[11] Sugiyono, *Memahami Penelitian Kualitatif* (Bandung: Alfabeta, 2012).

B. DISCUSSION

1. Polaris star as a fixed Circumpolar Star

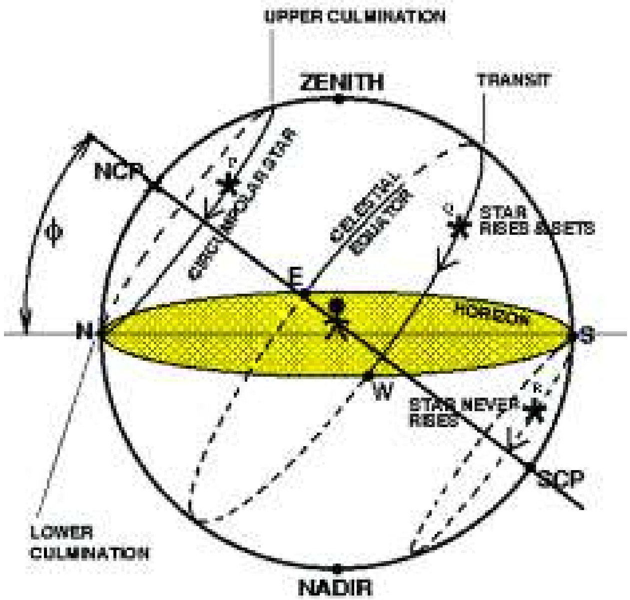


Figure 1: Circumpolar stars [12]

A circumpolar star is a star that appears to be constantly circling the poles. The upper and lower culminations remain above the horizon [13]. In the figure above, there is a star P which is a circumpolar star. The most popular circumpoler star is Polaris, which is the brightest star in the constellation of Ursa Minor. Polaris sits almost permanently above the north pole, from hour to hour, from night to night, and has guided explorers for centuries. Polaris is approximately 430 light years from Earth and is a multi-star system. Polaris has a right ascension of 2° 31' 49" and a declination of +89°15′51”. This means that the Polaris star is not positioned exactly at geographic north [14].

The northern constellation consists of stars which around the north pole and then are known as the northern circumpolerant stars [15]. Examples of the northern constellation are Ursa Minor and Ursa Major. In the constellation of Ursa Minor, there is Polaris. Observation

[12] The Nine Planets The Nine Planets, “What Are Circumpolar Stars? | Facts, Definition & Examples,” *The Nine Planets* (blog), 2021, https://nineplanets.org/questions/what-are-circumpolar-stars/.

[13] Markus Nielbock, “Navigation in the Ancient Mediterranean and Beyond – Brewminate,” 2018, https://brewminate.com/navigation-in-the-ancient-mediterranean-and-beyond/.

[14] McClure, “Polaris Is the North Star | Astronomy Essentials | EarthSky.”

[15] Aparna .T, V Keerthana, and I Aysha, “Determining Latitude of a Place Using Trigonometry,” *International Journal of Scientific Research* 5, no. 2 (January 1, 2018): 2321–0613.

of the altitude of Polaris can provide latitude for the observer. Some minor corrections had to be made, because Polaris was not directly above the north pole, but fluctuated. However, the changes are not so significant that this correction which is less than 1° can be considered insignificant for various purposes. Therefore, Polaris is very accurate as a guide for north or as a reference for calibrating north [16]. Polaris will be the North Star for centuries to come. However, Polaris wasn't always the North Star forever. In ancient times, the famous star named Thuban in the constellation Draco was the North Star when the ancient Egyptians built the Pyramids. Until recently, Polaris was a good North Star because it is the 50th brightest star in the sky. Polaris has guided humans to find their destination, for example, when Europeans first sailed across the Atlantic more than five centuries ago [17].

2. Polaris Star Positioning

The star Polaris is part of the constellation Ursa Minor. This constellation lies opposite the Ursa Mayor Constellation. The Ursa Major constellation consists of 7 main stars that can be seen with the naked eye including Dubhe (Alpha Ursa Majoris), Merak (Beta Ursa Majoris), Phecda (Gamma Ursa Majoris), Megrez (Delta Ursa Majoris), Alioth (Epsilon Ursa Majoris), Mizar (Zeta Ursa Majoris), and Alkaid (Eta Ursa Majoris). The Ursa Mayor constellation is easily recognized if the observer has seen at least 5 stars from this constellation, namely 4 stars that form a trapezoid-like quadrilateral and 1 star which is part of the stem.

To determine north point using the Ursa Mayor constellation, two methods can be used:

a. *Method 1 (used when Polaris is visible)*

For regions that are far north of the equator (latitude above 10° N) such as India, Saudi Arabia, and countries close to the north pole, the north point can be determined easily because Polaris can be observed quite high above the horizon. Polaris is also the brightest star in the Ursa Minor constellation. North point that we will determine is exactly pointing to this Polaris star.

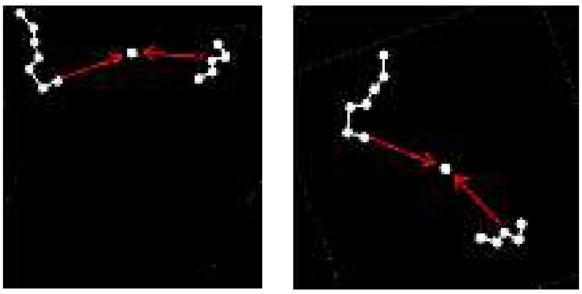
[16] R. Wielen et al., "Polaris: Astrometric Orbit, Position, and Proper Motion," *ArXiv:Astro-Ph/0002406*, July 21, 2000, http://arxiv.org/abs/astro-ph/0002406.

[17] McClure, "Polaris Is the North Star | Astronomy Essentials | EarthSky."

Figure 2: Way to find Polaris [18].

The closer to the north pole, the easier it is to identify the appearance of Polaris based on the Ursa Major or Ursa Minor constellation because Polaris is part (the end) of the Ursa Minor constellation. If guided by the constellation Ursa Mayor, Polaris can be identified by its location by drawing a straight line starting from star β to star α in the constellation Ursa Mayor. The star β and star α are usually called pointer stars.

On the other hand, another constellation that can be used to point Polaris is the constellation which looks like the letter W. This constellation is called Cassiopia. This constellation is only seen in northern latitudes closer to the poles such as Canada, Norway, Sweden, and northern Russia. In these countries, the Ursa Mayor and Cassiopia constellations appear high above the horizon. For areas in moderate latitudes such as 30o to 60o north latitude such as the United States, Europe, Romania, Russia, China and Mongolia, the polar star appears at a lower altitude in the middle of the sky. The method of determination is as follows.



A B

Figure 3: Ursa Major Constellation and Cassiopia as pointer to Polaris at high latitude (a) and moderate latitude (b) [19]

[18] Bonč, *English: Finding Polaris*, April 23, 2010, April 23, 2010, based on file:Ursa Major and Ursa Minor Constellations.jpg, https://commons.wikimedia.org/wiki/File:Ursa_Major_-_Ursa_Minor_-_Polaris.jpg.

As for low latitudes (close to the equator) such as the southern United States, the Caribbean, North Africa, the Middle East, India and Hong Kong, the appearance of Polaris is still clearly visible. However, the Ursa Mayor and Cassiopia constellations do not appear at the same time.

A B

Figure 4: Appearance of Ursa Major and Cassiopia constellations as pointers to Polaris at low latitudes [20]

b. Method 2 (used when Polaris is invisible)

In areas near the equator such as Sambas, Kuala Lumpur, Lhoksmawe, and its surroundings, the Polaris star is difficult to observe because it is very low above the horizon, which is in accordance with the latitude of each location. However, the north direction can be estimated by looking for the Ursa Mayor constellation. We do this by drawing a straight line through the α-β star in the constellation Ursa Mayor. The distance between the star α Ursa Mayor to Polaris is five times the length of the α-β Ursa Mayor line. Look at the following picture.

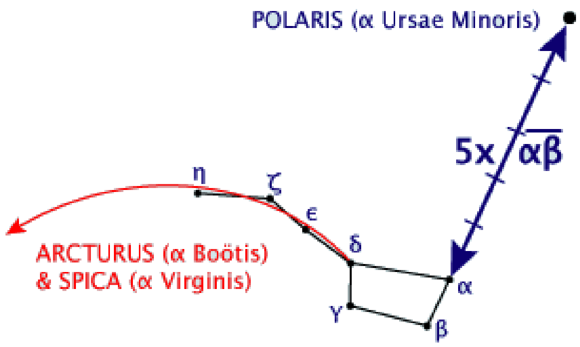


Figure 5. How to determine the location of the Polaris star using method 2[21]

Suppose we make observations in the sky for Sambas area, Indonesia with coordinates of latitude 1o 22 '52 "N and longitude 109o 19' 3,4" E to determine the north direction using Polaris. The observer must first locate the constellation Ursa Mayor. It is better if

[19] satsig.net satsig.net, "North Pole Star.," How to find the north pole star, 2021, https://www.satsig.net/maps/how-to-find-north-pole-star.htm.

[20] satsig.net.

[21] McClure, "Polaris Is the North Star | Astronomy Essentials | EarthSky."

observers already know the time of appearance of this constellation through the help of applications or software such as Stellarium and the like. The appearance of this constellation is illustrated as follows.

Figure 6: Appearance of the Ursa Mayor Constellation on January 17 at 1:15 a.m in Sambas West Kalimantan, Indonesia [22]

If the star α-β Ursa Mayor is x cm, then Polaris is located 5x cm from the star α Ursa Mayor. Polaris location can be estimated by drawing a line as shown in the following figure.

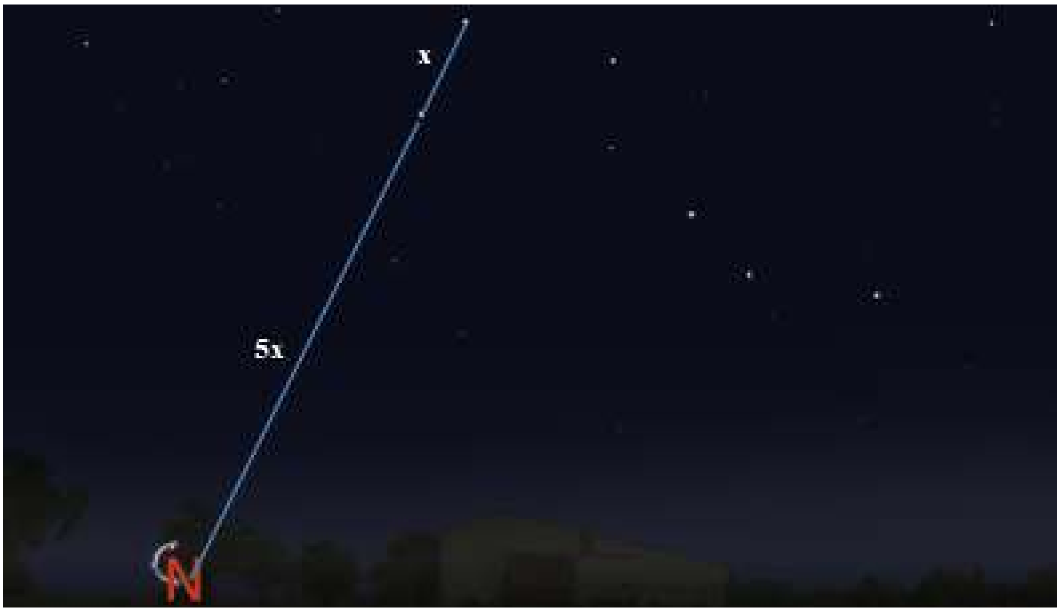


Figure7: How to Draw 5x lines through 2 stars of the Ursa Mayor constellation [23]

[22] Stellarium Stellarium, "Stellarium Weab Online Star Map," 2021, https://stellarium-web.org/.
[23] Stellarium.

3. Theoretical Study of the Accuracy of the Use of Polaris in Determining the Qibla Direction

The Qibla direction is a necessity for every Muslim in the world, both in determining the direction of mosque buildings and for other buildings such as houses, hotels, schools, and so on [24]. In its determination, the method that is often used is calculation methods. The result of calculations, using either the spherical triangle method or the Vincenty formula, is the value of the Qibla direction (angle) from true north. Therefore, determining true north is an important part of the method of determining the Qibla direction. The best direction for north at this time is Polaris. Polaris is fixed star that are easily visible throughout the year, especially in high latitudes. Because it is a fixed star, Polaris never sets like the Sun and other stars. However, if the determination is made using observations, Polaris is difficult to determine without the Ursa Major constellation as a clue. The Ursa Major constellation can be clearly observed (the constituent stars are complete) for most of the year, except in September and October [25]. The rising time of this constellation also varies, from early morning (dawn) to the time after sunset.

For the use of Polaris in determining the direction of the Qibla, this discussion will categorize the hemisphere into two parts, namely the regions located at latitude 0^o-10^o N and the regions located at latitude above 10^o N.

1. *For regions located at latitude 0^o-10^o N*

In this region (such as Southeast Asian countries), Polaris is difficult to see or even invisible due to its very low appearance. In addition, this region includes countries with wet tropical climates with high rainfall so that the sky is often full of cloud which makes it difficult to observe Polaris due to its very low position on the Horizon. However, with the help of the Ursa Major constellation, Polaris can be estimated by taking a distance of 5 times the distance of the α-β star. Because of Polaris is not visible, the results of determining the north direction are still approximate (dzanniy). Thus, for the purposes of determining the Qibla direction using this method, the results are less accurate. In addition, to draw a line 5 times the length of the α-β star, special observation equipment such as binoculars and others are absolutely needed and must be calibrated to take 5 times the distance from α-β stars.

[24] Hendri Hendri, "PRAYER ROOM QIBLA DIRECTION AT SCHOOL IN BUKITTINGGI : (Qibla Study in Junior High School and Senior High Schools Prayer Room)," *Al-Hilal: Journal of Islamic Astronomy* 1, no. 1 (October 1, 2019), https://doi.org/10.21580/al-hilal.2019.1.1.5189.

[25] Stellarium, "Stellarium Web Online Star Map."

2. *For areas located at latitude above 10o N*

For regions in latitudes above 10o N such as the southern United States, Saudi Arabia, the Caribbean, North Africa, the Middle East, India, Hong Kong, China, and Russia, Polaris can be clearly observed through the α-β star pointer of the Ursa Major constellation. Polaris will never set and will appear high above the horizon at night when the weather is good. Using Theodolite, the true north point can be determined quite easily. The use of the theodolite in determining north is to place the Polaris shot in the center of the telescope on the theodolite. After being aimed right at the center of the telescope, lock the theodolite. Next, rotate the theodolite horizontally according to the angle or azimuth of the Qibla direction based on the calculation before. After the theodolite points to the Qibla, then the direction of the theodolite telescope is projected on the plane or floor so that a straight line is obtained that leads to the Qibla. The way is to lower the telescope's aim to the floor (mark with Spot A) and lower it lower again (marked with dot B). Then connect point A and point B to obtain a line leading to the Qibla.

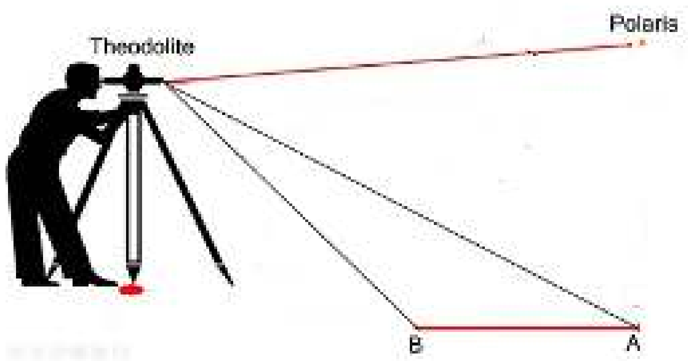


Figure 8: Aiming Polaris and projecting the Qibla direction

Accuracy of Qibla direction using Polaris as reference of north point can be considered to be accurate because observers can see the true north point. In addition, this method is not influenced by external factors such as ferrous metal as experienced by the compass. If the aiming is carried out correctly according to the procedure, the results will be accurate. Of course, deviations can occur if the aiming is not careful and the projection between the two points is incorrect. In order to realize facing the Qibla to the 'ain of the Ka'ba, regions which located in latitude above 10° N have more potential to achieve this as long as it is carried out with great care to reach the north point with a precise and accurate reference to Polaris.

C. CONCLUSION

In regions near the equator, Polaris is difficult to observe because it is so low above the horizon. However, the north direction in the region can be estimated by looking for the Ursa Major constellation by drawing a straight line through the α-β stars where the distance between the α-β stars Ursa Major to Polaris is five times the length of the α-β line. Because Polaris is not visible, the results of determining the north direction are still approximate (dzanniy). Thus, for the sake of determining the Qibla direction using this method, the results are inaccurate. To draw a line 5 times the length of the α-β star, special observation equipment such as binoculars and others are needed and must be calibrated

For areas far north of the equator (in latitude above 10o N), north point can be determined easily because in this northern hemisphere, Polaris can be observed by Theodolite quite high above the horizon. The use of the theodolite in determining the direction of north is to target the Polaris shot in the center of the telescope of theodolite. After being aimed right at the center of the telescope, lock the theodolite. Next, rotate the theodolite horizontally according to the angle or azimuth of the Qibla direction based on calculation. After the theodolite points to the Qibla, then the direction of the theodolite telescope is projected on the plane or floor so that a straight line is obtained leading to the Qibla.

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