Mapping the Direction to Makkah: A Cartographic Perspective

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Abstract

This paper would normally appear in a journal of cartography. We decided, nonetheless, to publish it in AJISS because it well illustrates the need to incorporate interdisciplinary approaches when addressing questions that fall under the category of the Shari`a. The paper reiterates a point often repeated in AJISS and reminds us of the need to redesign the curriculum of Shari`a schools so as to allow the graduates to have a deeper understanding of social and natural phenomena.

– Editor

Introduction

Knowledge of locations and directions using the stars was almost instinctual for Arabs during the pre-Islamic era. Being an illiterate nation, using the pen to record information was very limited and hence the art and science of map-making was almost non-existent. It was not until Islam, that the use of the pen became a necessity of everyday life. The importance of keeping written records became evident especially when the Muslim Empire expanded beyond the Arabian Peninsula. In a very short time the Muslims were able to conquer scientifically more advanced nations such as the Byzantine and Persian empires. Geographical records and maps, inherited from the ancients were translated into the Arabic language and modi-

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fied to encompass the Islamic vision of the world of geography. Elements of nature such as the wind, the mountains and seas that were previously feared by nations are no longer gods to be worshiped, but rather signs of Allah's creations to be studied.

Geographic information was both descriptive and literal in nature, supported by maps. Mathematical equations that can determine locations of the stars were engraved on mechanical tools such as the astrolabe. Records of the use of spherical trigonometry in geography can be traced back to the ninth century CE (third century AH).[1]

While Islamic teachings encourage scientific research in general, the second pillar of Islam, that is prayer, demands awareness of time and location. In order to perform the prayer correctly, a person has to pray five times a day, according to specific timings while facing the city of Makkah. The sacred direction (*qibla*) toward Makkah also influenced other aspects of the Muslim life such as architecture and burial rites. The concept of sacred direction was not new; Jews and Christians used Jerusalem as a geographic center for their religion.[2] During the early revelations of Islam, Muslims used Jerusalem for the same purpose as well. The Islamic teaching later changed the sacred direction to Makkah and made it a condition for correct prayer. This drove the Muslims to a higher level of sophistication in solving the problem of determining directions.

Two major approaches to determine the direction to Makkah can be recognized. The first is the folk astronomy (ethnoastronomy) where the scholars of the sacred law of Islam (*fuqaha'*) have a major influence on interpretation and are related more toward the spiritual aspect of the problems. The second is the mathematical method where a high level of calculations and technical solutions were applied by professional scientists.[3]

This paper argues that the gap between the two approaches is not large and their historical evidence shows an actual merging of the two approaches. Such evidence is found in many maps and calculations of Islamic literature throughout history. The two seventeenth-century Iranian maps introduced by David A. King (1999) of the Old World (discovered in 1989 and 1995) with Makkah at the center, as well as similar maps found in (Harley and Woods 1992) are good examples. *Qibla* tables and mechanical devices such as the astrolabe are other examples.[4] The vast number of mosques built by early Muslim immigrants in the Americas with the correct direction to Makkah is a very good indication that the difference between the two approaches is minimal and that the confusion over the correct direction is very limited.[5]

In modern times, with the implementation of computer technology, producing maps in various projections becomes a matter of choice. Once geographic information is recorded in digital form, maps can be produced in any desired projection. While the same technology enhances our geographical knowledge by introducing it in a visual form, for the layman it can be confusing when it comes to directions. Modern maps, made from a western perspective, do not necessarily provide or display information such as great circles centered on Makkah. For a casual map user, the direction to Makkah from the United States on a Mercator projection map seems to be to the southeast. This confusion extended in some cases to professional geographers who, when asked for directions to Makkah, used the rhumb line as a solution.[6] Part of the problem is due to a lack of scientific understanding of the Islamic teaching regarding the prayer direction.[7]

In a previous paper,[8] the author introduced the concept of the prayer circle (PC) and prayer direction circle (PDC) system to help simplify the problem. This paper combines these concepts with spherical triangulation and cartographic design to offer a visual solution to the problem by using Geographic Information Systems (GIS).

Prayer Circle and Prayer Direction Circle

To better understand the Islamic perspective of the problem, one has to go to its geographical basis. The Quran is very specific about using the Ka'bah (the great mosque in Makkah) as a focal point (*qibla*). When Muslims gather in Makkah, they pray in a circle around the Ka'bah. This is called the prayer circle.[9] The circles obviously start small around the Ka'bah's cubic structure and continue to grow larger until they constitute a great circle. The circles then grow smaller again until reaching a point opposite Makkah on the other side of Earth. At that point, a person could perform prayer in any direction. In order for a person to be praying facing the Ka'bah, the direction of the prayer has to be perpendicular to the prayer circle. Persons standing behind each other are located on a prayer direction circle.[10] This is a great circle formed by the persons and the Ka'bah. Figure 1 shows the PC/PDC system.

In order for the PC/PDC system to be presented on a map, in a similar fashion to the graticule system of Latitude and Longitude (Lat/Lon), two reference points on the earth's surface are needed. Makkah is the primary point, simply because it is the focal point or the point of destination (similar to the North Pole). A secondary point has to be selected to create a prime

Figure 1. The PC/PDC system (Modified from Massasati 1994).

PDC (similar to Greenwich in England). For this paper, the city of Madinah is selected because it is the second holy city for Muslims.

Calculation of the PC/PDC

A spherical triangulation solution[11] has been applied on a 10° interval PC/PDC system. The vertices of the system are computed using spherical triangulation. In the spherical triangle (Figure 2), C is located at the North Pole, The City of Makkah at B and the calculated vertex is located at A. The first step is to calculate the vertices of the prime PDC. The Lat/Lon of the cities of Makkah and Madinah are 21° 27'N, 39° 45'E and 24° 26'N, 39° 42'E, respectively. Using the following spherical triangulation equations:

The calculated azimuth from Makkah to Madinah is 0.8745912 degrees west. Using the Makkah-Madinah prayer direction as a prime PDC, the same equations were used to determine the coordinate of vertices on a great circle by using a ten-degree interval for each calculation. PDCs vertices were calculated by adding intervals of 10° to the Makkah–Madinah direc-

Figure 2. The spherical triangle.

$$\tan 0.5 (B + A) = \cos 0.5 (b - a) \sec 0.5 (b + a) \cot 0.5 C$$
$$\tan 0.5 (B - A) = \sin 0.5 (b - a) \csc 0.5 (b + a) \cot 0.5 C$$
$$\tan 0.5 c = \tan 0.5(b - a) \sin 0.5 (B + A) \csc 0.5 (B - A)$$

Where: sec = 1/cos, csc = 1/sin, and cot = 1/tan.

tion to cover the entire globe. Table 1 shows part of the Lat/Lon calculations of PDC/PC vertices. Each two columns on the table show the calculation of the Lat/Lon of each vertex in decimal degrees. Lat (0-180) and Lon (0-180) on column one and two are the calculated Lat/Lon for the prime PDC. For the PC circles, the Lat/Lon calculation starts at a PC (180) in the other side of the earth at Lat/Lon -21.45/ -140.25. The calculation reaches PC (0) at the city of Makkah where Lat/Lon is 21.45/39.75. The calculations continue for the other side of the PCs till reaching the anti Makkah point.

Table 1. Calculated vertices of the PDC/PC system (part of the full 18x36 matrix).

PDC	Lat(0-180)	Lon(0-180)	Lat(10)	Lon(10)			Lat (170)	Lon (170)
PC								
180	-21.45	-140.25	-21.45	-140.25	-	-	-21.45	-140.25
170	-31.45	-140.07	-31.26	-138.05	-	-	-11.57	-138.64
160	-41.45	-139.85	-41.01	-135.34	-	-	-1.68	-137.14
-	-	-	-	-	-	-	-	-
40	-18.55	39.16	-17.9	32.43	-	-	60.56	27.78
30	-8.55	39.31	-8.07	34.28	-	-	50.91	32.53
20	1.45	39.45	1.78	36.05	-	-	41.14	35.62
10	11.45	39.6	11.62	37.83	-	-	31.31	37.9
0	21.45	39.75	21.45	39.75	-	-	21.45	39.75
10	31.45	39.93	31.26	41.95	-	-	11.57	41.36
20	41.45	40.15	41.01	44.66	-	-	1.68	42.86
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
180	-21.45	-140.25	-21.45	-140.25			-21.45	-140.25

Note: All units are in decimal degrees.

The Lat/Lon values are both positive if the point is located Northeast, positive and negative if the point is located Northwest, both negative if the point is located Southwest, and are negative and positive if the point is located Southeast.

Visual Presentation

Once the PC/PDC are recorded in a computer form, presenting the circles on a map is a matter of personal preference and software capabilities. For example, figure 3 shows the Earth as seen from space using orthographic projection. The true azimuth to Makkah at a given point can be determined as the angle between the geographic meridian and the PDC at that point.

Figure 3. The PC/PDC on the world map as seen from space.

By choosing another map projection, the PC/PDC system can be presented to show the earth from a different perspective. Figure 4 shows a global perspective of the familiar Robinson projected map.

Figure 4. The PC/PDC system displayed on a Robinson projection of the world.

Figure 5 shows a regional perspective of North America with the PC/PDC system on a Miller Cylindrical projection. The map shows very clearly that the direction to Makkah is northeast except for Alaska where the direction to Makkah become due north.

Conclusion

Present day computer cartography and GIS technology make it possible to make maps that show geographical data from different perspectives.

Figure 5. The PC/PDC system on a Miller Cylindrical projection of North America.

The concept of drawing great circles to show proper directions to airports on maps has been used in present times. Publications and arguments summarized in Nashef and Kadi[12] are based on a visual presentation of Earth on a flat surface. In that case, information is "distorted" so that the direction to Makkah from places such as the United States of America seemed to be toward the southeast not the northeast. The PC/PDC system, though printed on flat surface, demonstrates very clearly that the correct directions in the USA are toward the northeast.

Notes

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5. Imad-ad-Dean Ahmad, review of *The Substantiation of the People of the Truth that the Direction of al-Qiblah in the United States and Canada is to the Southeast*, Riad Nachef and Samir Kadi, *Islamic Horizons* (September 1994): 41-43.

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9. Ibid.
10. Ibid.
11. Frank Ayres, Jr., *Schaum's Outline of Theory and Problems of Plane and Spherical Trigonometry*(New York: McGraw-Hill , 1954). (Schaum's Outline Series).
12. Nachef and Kadi, *The Substantiation.*