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Qibla Finder and Sholat Times Based on Digital Compass, GPS and Microprocessor

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Abstract. To performing Sholat, Muslims around the world are required to pay attention to the requirements of Sholat, such as; determining the direction of the Qibla (Kaaba) and the time of Sholat. In this research will be made a real time Qibla Finder and Sholat Times named Q-Bot Ver3 to help Muslims find a Qibla direction and Time of Sholat anywhere. This Qibla Finder and Sholat Times are developed with robotic technology based on Digital Compass, GPS and Microcontroller. To determine the Qibla direction and Sholat times, latitude and longitude data form GPS module processed used spherical triangle trigonometry method, while the compass module used to show the Qibla direction. Moreover, this system has a buzzer which can sound if the device facing to the Qibla. This system is reliable and accurate in determining the Qibla Finder and Sholat Times. Thus, the advantage of the system is can correct the Qibla of Masjid and can help blind people to facing Qibla around the world.

1. Introduction

Sholat (Muslims's pray) is the mandatory worship of Muslims who performed 5 times daily. Thus, must be pay attention the terms of Sholat such as facing the Qibla and performed Sholat when the time comes. For beginning decade, researchers developed a manual Qibla Direction and Sholat Times based on the length of the sun shadow, compass, and a mathematical method. For mathematical method, some researcher used Mathematical method of Muslims scientists who have done the research about Qibla previously, such as; Abu Al-Wafa [1] [2], Al-Biruni [3] [4], Ibn Al-Haytham [5], and other.

Nowadays, have been developed a technology to know the location with latitude and longitude (coordinate) named Global Positioning System (GPS). Moreover, algorithm program and microcontroller technology present to make automation any field. Thus, researcher combine some technology with mathematical methods that can be build The Qibla Direction and Sholat Times more sophisticated. The related work of Qibla Direction and Sholat Times which have developed by researcher based on GUI software [6] [7] [8], microcontroller [9] [10] [11] [12] [13] [14], and other.



In this research described a development of the real time Qibla Finder and Sholat Times based on Arduino microcontroller named Q-Bot Ver3. GPS (Global Positioning System) module used to determine of a location to get the Latitude and Longitude data. Then, the GPS data processed used trigonometry spherical triangle method to get the Qibla direction and Sholat time. The digital compass module used to determine Qibla Direction, and activated the buzzer sound when the device facing to Qibla. Finally, this system can be used to improve the direction of Qibla and Sholat time in the Masjid and can help blind people to know the Qibla around the world. The paper is organized as follows. In section 2, described the theoretical background and mathematical calculation solution using trigonometry spherical triangle method to determine Qibla Direction and Sholat Times of Q-Bot Ver3. The system design describes in section 3. In section 4, described a hardware design of Q-Bot Ver3. The result and discussion describe on section 5. Finally, the concluding remarks are given on section 6.

2. Theoretical background

2.1. Qibla direction

Qibla (mean "direction" from Arabic translation) is the direction of the wind that leads to the Kaaba at *Masjidil Haram, Makkah Al-Mukarramah* (Mecca), Saudia Arabia [15]. Calculation of the Qibla direction on Islamic education is studied in the science of *Falak* (astronomy). One method of studying the direction of Qibla is to use the trigonometry spherical triangle method have been developed by Muslims scientists [4], such as; al-Nayrizi, al-Quhi, Abu al-Wafa, al-Biruni, Ibn Mu'adh and other. The trigonometry spherical triangle is described as Figure 1 [16] [17] [18].

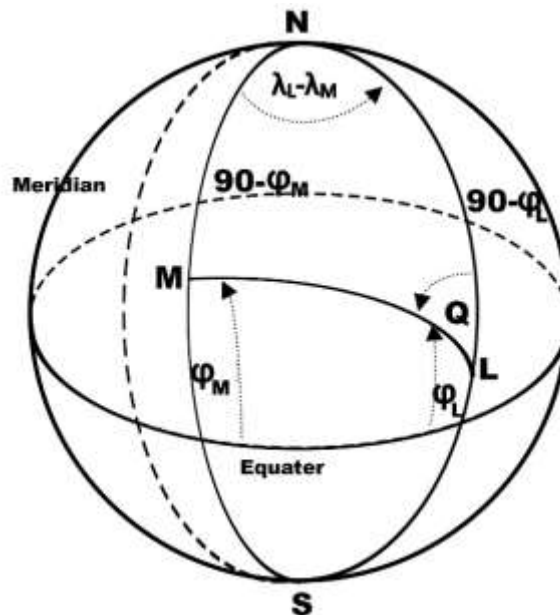


Figure 1. Trigonometry Spherical Triangle Illustration

From Google Earth, the location of Kaaba astronomically shown at Equation 1 (latitude) and Equation 2 (longitude).

$$\varphi = 21^{\circ}25'21.21''LU \quad (1)$$

and

$$\lambda = 39^{\circ}49'34.56''BT \quad (2)$$

From trigonometry spherical triangle formula [19], the equation to determine Qibla at some location show on Equation 3.

$$\tan(Q) = \frac{\sin(\lambda_L - \lambda_M)}{\cos\varphi_L \tan\varphi_M - \sin\varphi_L \cos(\lambda_L - \lambda_M)} \quad (3)$$

The Equation 3, describe:

- φ_M = Makkah (Qibla) Latitude, see Equation 1
- λ_M = Makkah (Qibla) Longitude, see Equation 2
- φ_L = The Latitude of some location
- λ_L = The Longitude of a location to determine Qibla direction.

2.2. Sholat times

Sholat is performed for 5 times daily, they are; *Fajr*, *Dhuhr*, *Asr*, *Maghrib* and *Isha*. Figure 2, describe the position of sun on celestial spherical. The prayer times on certain place different from other because of astronomical data latitude and longitude of a location. For explanation the times of *Sholat* and the mathematical formulation of each Sholat time [16] [20] [21] [22] [23], below:

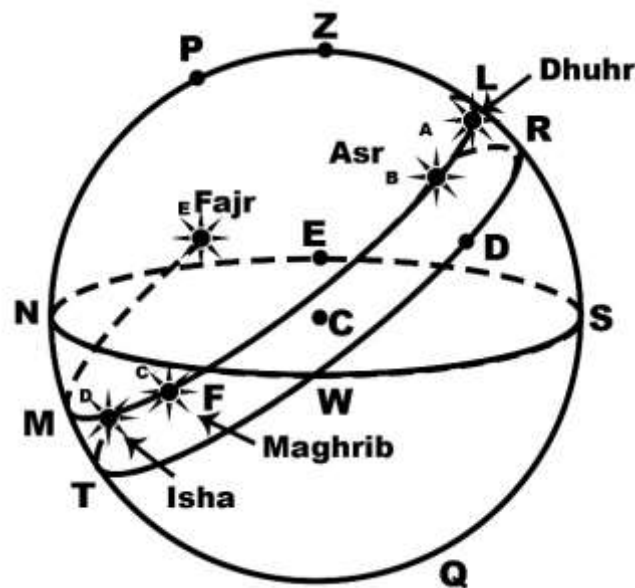


Figure 2. Position of Sun on Celestial Spherical

2.2.1. *Fajr* It starts with the dawn, when the morning twilight known as *Subh sadiq*. Fajr ends before sunrise.

$$Fajr = Dhuhr - HFajr = Dhuhr - \frac{1}{15} \cos^{-1} \left(\frac{-\sin AIT - \sin\varphi \sin\delta}{-\sin\varphi \sin\delta} \right) \quad (4)$$

Equation 4 describe the mathematical model of *Sholat Fajr*, Dhuhr is mathematical model from Equation 5, AIT (Astronomical Islamic Twilight) is -18° , φ is celestial latitude and δ is declination angle.

2.2.2. *Dhuhr* It begins after noon/midday, when the center of the sun is at the meridian. Dhuhr is performed after 5 min past to the zenith and ends when *Asr* time is start.

$$Dhuhr = 12^h + \frac{\lambda}{15} + \frac{E}{60} + 1^{min} \quad (5)$$

Equation 5 is the times model of *Sholat Fajr*, describe; $12h$ is *Zawal* time (12:00^h Noon), λ is Longitudinal differences ($\lambda = \lambda_{zoneTime} - \lambda_{Local}$) and E is the equation of time.

2.2.3. *Asr* It begins when the sun is at upper transit the shadow of vertical pole is minimum. The length of shadow = length of object + its length at noon.

$$Asr = Dhuhr + \frac{1}{15} \cos^{-1} \left(\frac{\sin a \cdot \sin \varphi \cdot \sin \delta}{\cos \varphi \cdot \cos \delta} \right) \quad (6)$$

The Equation 6 represent *Asr Sholat* time, where *Dhuhr* is Equation 5, where use *Madzhab Shafi* $a = \cot^{-1}(1 + \tan|\varphi - \delta|)$ or use *Madzhab Hanafi* $a = \cot^{-1}(2 + \tan|\varphi - \delta|)$, φ is celestial latitude and δ is declination angle.

2.2.4. *Maghrib* Begins at sunset, the center of the sun's disc below the horizon by 50 arcs minutes when the sun at 0.83° below horizon. *Maghrib* ends when *Isha* time is start.

$$Maghrib = Dhuhr + \frac{1}{15} \cos^{-1} \left(\frac{-\sin D - \sin \varphi \cdot \sin \delta}{\cos \varphi \cdot \cos \delta} \right) \quad (7)$$

From the Equation 7, describe; for *Dhuhr* see Equation 5, D is Depression angle is 0.833° , φ is celestial latitude and δ is declination angle.

2.2.5. *Isha* It starts after dusk, when the evening twilight disappears.

$$Isha = Dhuhr + \frac{1}{15} \cos^{-1} \left(\frac{-\sin AIT - \sin \varphi \cdot \sin \delta}{\cos \varphi \cdot \cos \delta} \right) \quad (8)$$

The *Sholat* time for *Isha* shown on Equation 8, describe that *AIT* (Astronomical Islamic Twilight) is -18° , *Dhuhr* shown on Equation 5, φ is celestial latitude and δ is declination angle.

3. Methods

3.1. System design

In this section will be describe the system design of *Qibla Finder* and *Sholat Times* named *Q-Bot Ver3*. The system generally based on GPS module, compass module and Arduino microcontroller. The algorithm of the system writes using Arduino IDLE. The steps in this research generally show in Figure 3.

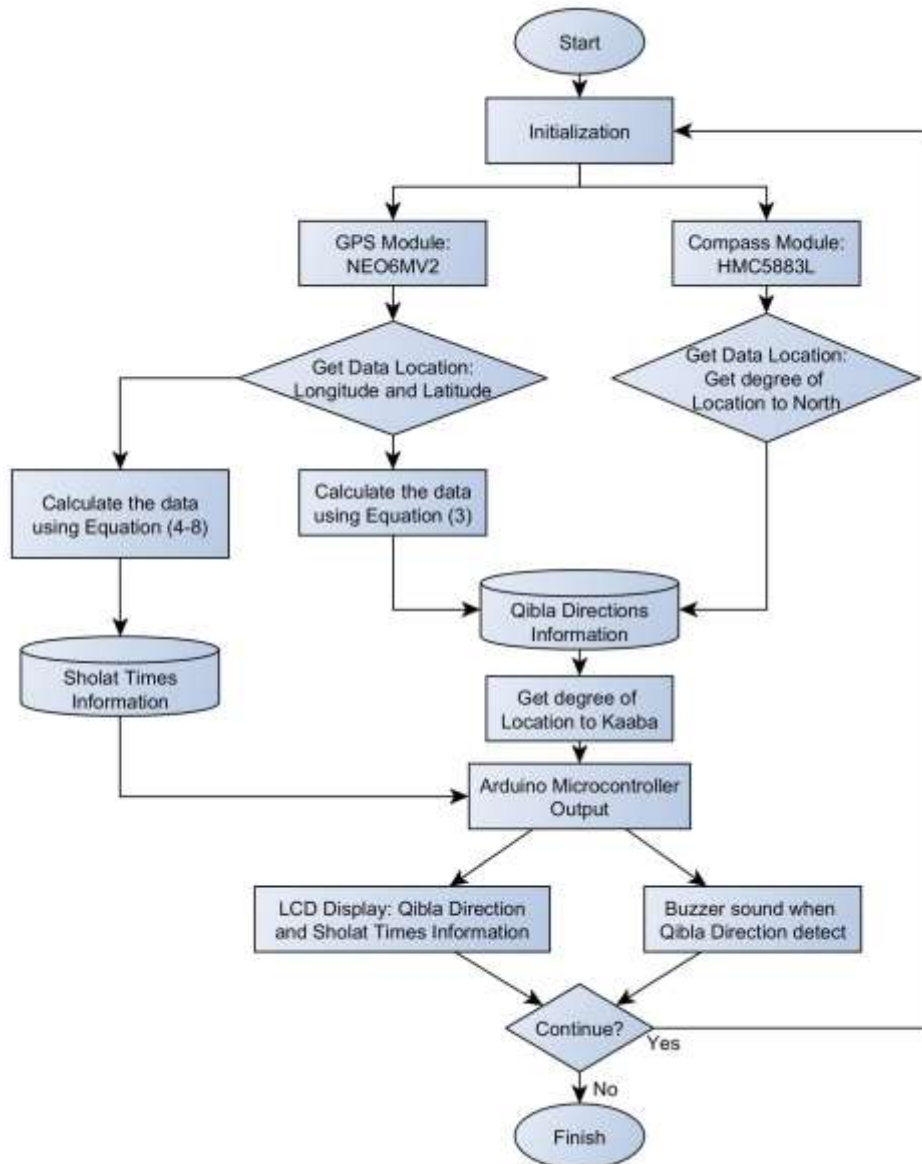


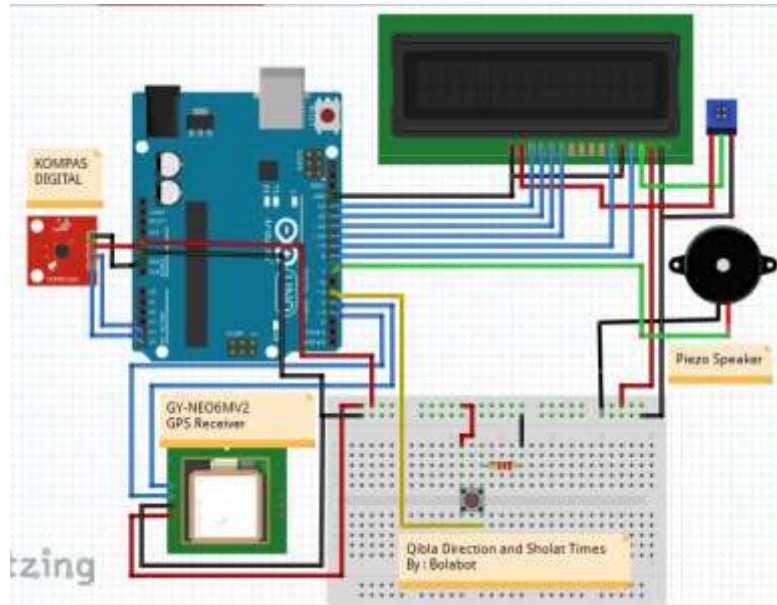
Figure 3. General System Scheme

From the Figure 3, after Arduino is active by power, automatically activate the GPS and Compass module. From GPS module will get the Longitude and Latitude data of Qibla and certain Location (which will know the Qibla Direction). Then, the GPS data going to calculate using Equation 3 and will get a Qibla data correction of a location (such as Masjid). While from the Compass module get the angle of a Location and North. The compass data calculated until get the angle a location toward Qibla. The obtained data from GPS and Compass will display on LCD and buzzer will sound when the system hardware leads to Qibla. In addition, get the Qibla Direction, Longitude and Latitude data will process using Equation 4-8. From the calculation, will get the Sholat Times of a Location. The Sholat Times information will be displayed on LCD.

3.2. Hardware design

The hardware system of Q-Bot Ver3 in this research consist by; GPS Module type NEO6MV2, Compass Module HMC5883L, Arduino board, buzzer, LCD 16x2, Personal Computer, Power

Bank and connections. Figure 4 are the realization and circuit schematic of the real time Qibla Finder and Sholat Times.



(a)Schematic Circuit



(b)Realization

Figure 4. Qibla Finder and Sholat Times Hardware System

From the Figure 4 (a) component connect to Arduino board pin, are; GPS connect to pin 4 (RX) and pin 3 (TX), Digital Compass connect to pin A4 and pin A5, buzzer connect to pin 7 and LCD connect to pin 13, 12, 11, 10, 9 and 8. Each ground of the component connected with ground, and some component needed connect to 5V of Vcc on Arduino microcontroller.

4. Results and discussion

4.1. Qibla direction

Data GPS and Compass processed by trigonometry spherical triangle formulation (see Equation 3) which will generate the Qibla direction and the correction data of Masjid. After build the Qibla direction system, the system tested (calibrated) in several places around Komplek Permata Biru, Cileunyi, Kab. Bandung, Indonesia. For taking the direction of Qibla direction. Q-Bot system is placed parallel to the direction of the carpet or floor of a Masjid, see Figure 5.



Figure 5. Collecting the Data of some Masjid

The results of the data collection of some Masjid shown in Table 1. The table show the values of the Qibla Direction (Q) and the correction (*Koreksi*) values Qibla direction from some Masjid. From the data table shows that the correction value of some Masjid have deviation value is quite distorted. Therefore, require to correcting the Qibla Direction of some Masjid in the way correcting the carpet direction.

Table 1. The Qibla Direction and Correction Some Masjid around Komplek Permata Biru, Cileunyi, Kab. Bandung, Indonesia

Masjid Name	Qibla Direction (Q)	Correction
Al-Hikmah	295.1470642	0.3613
Mukhlisiina Lahuddin	295.164233	-0.951
Darussalam	295.1450805	-0.96
Darul Fikri	295.148529	-0.962
Muhajirin	295.1461791	-0.97
Ash-Shiddiq	295.148529	1.9001
Baiturrahman	295.1482849	-0.261

In addition, Q-Bot have a Buzzer which will sound if facing Qibla direction. Thus, this system can help blind people to facing (navigate) Qibla direction to implement Sholat anywhere because this system is easy brought everywhere.

4.2. Sholat times

The Sholat Time system based on Arduino, GPS, and a mathematical calculation of each Sholat Time. Noted that Komplek Permata Biru is an area of the Kab. Bandung Indonesia has GMT +7 of time zone. The Latitude and Longitude from GPS and GMT data processed to the Equation 4-8 and get a Sholat Times. Figure 6 show the interface result of Sholat Times at Komplek Permata Biru, Cileunyi, Kab. Bandung, Indonesia. The Sholat Times information

shown in Indonesian consist by; Fajr(*Subuh*), Dhuhr(*Zuhur*), Asr(*Ashar*), Maghrib(Maghrib), Isha(*Isya*) and Time (*Jam*). The prayer times on certain place different from other because of astronomical data latitude and longitude of a location.



Figure 6. The Sholat Times Information of a Location from Q-Bot Ver3

6. Conclusion

The development of Qibla Direction and Sholat Times named Q-Bot Ver3 have been presented which have can display the Qibla direction and Sholat times. In this research, the spherical triangle trigonometry method used to determine the Qibla direction and Sholat times from Latitude and Longitude data of a location. Q-Bot Ver3 are developed with robotic technology based on Digital Compass, GPS and Arduino Microcontroller works well. While, the interfaces of Sholat Times information have been developed on Arduino. In addition, the Qibla Direction equipped a Buzzer which can sound when the device facing Qibla, thus this system can be used by blind people. The system has been test to correcting the Qibla direction of some masjid around Komplek Permata Biru, Cinunuk, Kab. Bandung, Indonesia. The future works of this research will enhance the interfaces and building a better portable Qibla Direction and Sholat Times system.

Acknowledgments

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