

RUKYATUL HILAL INSTRUMENT DESIGN BASED ON ARDUINO

Fajrullah¹, Zikrullah Hadi², Andi Evan Nisastra³.

^{1,3}Universitas Islam Negeri Walisongo Semarang-Indonesia, ²Universitas Tadulako Palu-Indonesia
¹fhajar877@gmail.com, ²zikrullahd@gmail.com, ³andievan9@gmail.com.

Abstract

Arduino is a Microcontroller platform consisting of a computer chip that is used to control electronic equipment that is flexible and easy to use. In this modern era, the implementation of *Rukyatul Hilal* can be done using instruments such as *Hilal* locater, telescope and theodolite. However, these tools are quite expensive and have a fairly heavy load and require long time to prepare. Therefore, this research provides breakthroughs and new innovations in designing the *Rukyatul Hilal* Instrument based on Arduino. The research uses the Research and Development model type of research, the development model that the researcher will do is to develop an Arduino Microcontroller so that it can be used as a *Rukyatul Hilal* Instrument. Based on 4 observations of the Moon, The Arduino-based *Rukyatul Hilal* instrument can successfully show the position of the Moon and verify the data used by the author is correct and the author can also photograph the image of the Moon clearly using a smartphone. However, it should be noted that the position of the Moon when viewed from the Arduino-based *Rukyatul Hilal* Instrument telescope is not in the middle of the telescope, but sometimes at the bottom, side and top.

Keywords: microcontroller; arduino; Rukyatul Hilal

Abstrak

Arduino merupakan salah satu platform Mikrokontroler yang terdiri dari chip komputer yang digunakan untuk mengontrol peralatan elektornik yang bersifat fleksibel dan mudah digunakan. Di era modern ini, pelaksanaan Rukyatul Hilal dapat dilakukan menggunakan instrumen-instrumen seperti gawang lokasi, teleskop dan theodolite. Namun, alat-alat ini memiliki harga yang cukup mahal dan memiliki beban yang cukup berat serta membutuhkan waktu yang cukup lama dalam mempersiapkannya. Oleh karena itu, penelitian ini memberikan terobosan dan inovasi baru dalam merancang Instrument Rukyatul Hilal berbasis Arduino, Penelitian menggunakan jenis penelitian *Research and Development* model pengembangan, Model pengembangan yang peneliti akan lakukan adalah mengembangkan Mikrokontroler Arduino agar dapat digunakan sebagai Instrumen Rukyatul Hilal. Berdasarkan 4 kali percobaan pengamatan Bulan, Instrument Rukyatul Hilal berbasis Arduino dapat berhasil menunjukkan posisi Bulan dan memverifikasi data yang digunakan penulis dengan benar serta penulis penulis juga dapat memotret citra Bulan dengan jelas menggunakan *smartphone*. Namun yang perlu diperhatikan yaitu posisi Bulan ketika dilihat dari teleskop Instrument Rukyatul Hilal berbasis Arduino tidaklah berada ditengah-tengah teleskop, melainkan kadang berada di bawah, samping dan atas.

Kata kunci: mikrokontroler; arduino; Rukyatul Hilal

A. Introduction

Determining the beginning of the month with the *Rukyatul Hilal* empirically is also a form of obedience to religious orders, namely the Sunnah of the Prophet Muhammad SAW. So that *Rukyatul Hilal* is included in the category of obedience in worship because it is a medium of fasting. The determination of the beginning of the month with *Rukyatul Hilal* or *istikmal* is held by the majority of Ulama, starting from the traditional to contemporary. The basis of this opinion is the hadiths narrated by Al-Bukhārī, Muslim, Abū Dāwud and al-Dāruqūṭnī.¹

One of the instruments used by *Rukyatul Hilal* is the *Hilal* locater, the *Hilal* locater in its application has a few drawbacks, namely in preparing it takes a long time because it has to take into account the exact position of the placement. In addition, the *Hilal* locater also still needs other tools such as a compass to determine the direction and make a *rukya*t map. Because the system is still manual, there is also room for error in the placement of the *Hilal* locater, such as the position of the target pole or the locater being not straight.² Like the *Hilal* locater, the theodolite also takes a long time to prepare, because it must first aim for true north as a reference for the *Rukyatul Hilal* observation point.³ The working principle of the telescope is the same, before it is used in the *Rukyatul Hilal*, it must be calibrated first so that when it is used the telescope can point to the *Hilal*. This takes quite a long time and not everyone can use these instruments because they are quite expensive, ranging from dozens to millions of rupiah.

Along with the development of the times and science and technology (Science and Technology) is so great, the things above can be overcome by developing the Arduino Microcontroller as an Instrument in *Rukyatul Hilal*. Arduino itself is an open-source electronic prototyping platform and its hardware based on its flexible and easy-to-use hardware and software.⁴

¹Zainul Arifin, *Ilmu Falak Cara Menghitung dan Menentukan Arah Kiblat, Rashdul Kiblat, Awal Waktu Shalat, Kalender Penanggalan, Awal Bulan Qomariyah (Hisab Kontemporer)* (Yogyakarta: Lukita, 2012), 101.

²Siti Tatmainul Qulub, "Lmu Falak dari Sejarah ke Teori dan Aplikasi" (Depok: Rajawali Pers, 2017), 263.

³Qulub.272.

⁴Jauhari Arifin, Leni Natalia Zulita, and Hermawansyah Hermawansyah, "Perancangan Murottal Otomatis Menggunakan Mikrokontroller Arduino Mega 2560," *Jurnal Media Infotama* 12, no. 1 (2016): 90.

The price of Arduino is relatively cheap compared to the price of the hilal locator, theodolite and telescope and Arduino *can* also be used on all computer operating systems, it can be windows, Linux or MacBook.⁵ The types of Arduino include: Arduino USB, Arduino serial, Arduino mega, Arduino Fio, Arduino LilyPad, Arduino BT and Arduino nano.⁶ Because it is open-source, everyone can access Arduino even if it is not a programmer. There are several previous works that explore Arduino in the field of astronomy, namely, Luqman Hakim, Rifqi Budi Raharjo and Didik Waluyo, "Robot Prototype to Determine Qibla Direction with Prayer Shaf Signs". National Student Scientific Week for Student Creativity Program - Karsa Cipta 2013. Lukman et al use Arduino Mega 2560 as a microcontroller as used by researchers. While the compass uses the CMPS10 Digital Compass.⁷

Then Aziz Zainuddin, Akhmad Hendriawan, Hary Oktavianto, "Qibla Direction Digital Compass with Visual Output". Aziz et al use Arduino Mega 1280 as Microcontroller, GPS EG-T10 and CMPS03 digital compass. This system is able to show the Qibla direction with an Error value of 0.19% degree.⁸ Then research from Fahmi Fardiyani Arief, Muchlas, Tole Sutikno, "Digital Compass with AT89S52 Microcontroller Based Sound Output". Fahmi et al designed a Digital Compass which is equipped with sound output, so that even the blind can use it.⁹ Then research by R. Apip Miptahudin, M. Aris Risnandar, "Test Qibla Direction Correction at the Gedhe Kauman Mosque, Yogyakarta Using a Digital Compass and Arduino Microcontroller". This research has developed a tool that can determine the Qibla direction based on a digital compass. The testing of this tool was carried out at the Gedhe Kauman mosque, Yogyakarta. The result shows that the Qibla direction is located at 294.7148437 with a correction of -0.35.¹⁰

⁵Junaidi dan Yuliyah Dwi Prabowo, *Project Sistem Kendali Elektronik Berbasis Arduino* (Bandar Lampung: Anugrah Utama Raharja, 2013), 4.

⁶Muhamad Royhan, "Pengukuran Tegangan Baterai Mobil dengan Arduino Uno," *Jurnal Teknik Informatika* 6, no. 1 (2018):31.

⁷Luqman Hakim, Rifqi Budi Raharjo, and Didik Dwi Waluyo "Prototype Robot untuk Menentukan Arah Kiblat dengan Tanda Shaf Sholat" Pekan Ilmiah Mahasiswa Nasional Program Kreativitas Mahasiswa - Karsa Cipta (Surabaya, 2013). 1.

⁸Aziz Zainuddin, Akhmad Hendriawan, and Hary Oktavianto, "Kompas Digital Penunjuk Arah Kiblat Dengan Output Visual," n.d. 1

⁹Fahmi Fardiyani Arief, Muchlas and Tole Sutikno, "Kompas Digital dengan Output Suara Berbasis Mikrokontroler AT89S52," n.d., 1.

¹⁰R. Apip Miptahudin and M. Aris Risnandar, "Uji Koreksi Arah Kiblat di Masjid Gedhe Kauman Yogyakarta Menggunakan Kompas Digital dan Mikrokontroler Arduino," *AlJazari: Journal Mechanical Engineering* 3, no. 2 (2018): 40.

Then Abdul Rafid Fakhrun Gani et al, "Qibla Direction Automatic Prayer Mat Prototype with Microcontroller Arduino", by using the CMPS 12 sensor as a Qibla direction detector and assisted by a dc motor can stabilize the Qibla direction when the vehicle turns direction automatically. As is this product is not only intended to make it easier for Muslims when praying in the vehicle as well serves to give peace when praying because it always faces towards the Qibla so that the conditions for valid prayer are met properly.¹¹ Based on the studies above, no one has specifically discussed Arduino as a *Rukyatul Hilal* Instrument. So, this research deserves to be researched and explored further.

B. Methods

The type of research that the author uses is research development or Research and Development model, the development model that researchers will do is develop an Arduino Microcontroller so that it can be used as a *Rukyatul Hilal* instrument. This study uses the primary source of the book Introduction to Arduino, A piece of cake. The work of Alan G. Smith, which contains the basic structures of Arduino programming and design.¹² The author collects data using the method of documentation and observation. Then the author analyzed the Arduino data in determining true north with the *Mizwala* Instrument and the Sun's shadow method before and after *Zawwal* (Culmination).

C. Results and Discussion

C.1 Arduino Overview

Before discussing Arduino, we must first know what is a microcontroller? Microcontroller is a computer chip that is used to control electronic equipment that regulates efficiency and cost effectiveness. Technically, the microcontroller is divided into 2 types, namely RISC (Reduced Instruction Set Computer) and CISC (Computer Complex Instruction Collection), RISC is limited but with many facilities while CISC has more

¹¹Aji Ibnu Khair Abdul Rafid Fakhrun Gani, Yul Ifda Tanjung, Abdul Rasyid Fakhrun Gani Muhammad Jaka Maulana and Ilham Sidiq, "Prototipe Sajadah Otomatis Arah Kiblat dengan Mikrokontroler Arduino," *Einstein (eJournal)* 10, no. 1 (2022): 42.

¹²Alan G. Smith, *Introduction to Arduino: A Piece of Cake!* (California: Create Space, 2011), 1.

complete instructions with limited facilities.¹³ Microcontroller is also referred to as one of the basic parts of a computer system. Despite having a much smaller form factor than a personal computer and mainframe computer, microcontrollers are built from the same basic elements. In simple terms, the computer will produce a specific output based on the input received and the program being executed. Like most computers, the microcontroller is a tool that carries out the commands given to it. That is, the most important and main part of a computerized system is the program itself which is made by a programmer.¹⁴

One of the microcontrollers that is often used by people is Arduino. Arduino is a microcontroller with a simple open source physical computing platform. What is meant by a physical computing platform is an interactive physical system with the use of software and hardware that can detect and respond to situations and conditions that exist in the real world. On the official website, Arduino is defined as an open source electronic platform, based on flexible and easy-to-use software and hardware, which is intended for users and anyone interested in creating interactive objects or environments.¹⁵ The author uses Arduino Mega 2560, because Arduino Mega 2560 has a high specification, equipped with digital pins, analog pins, serial ports.¹⁶



Figure 1: Arduino Mega 2560. Board

¹³Muhammad Irfan Hafidhin et al., "Alat Penjemuran Ikan Asin Berbasis Mikrokontroler Arduino Uno," *Jurnal Teknik dan Sistem Komputer* 1, no. 2 (2020): 60.

¹⁴Rahmad Genaldo et al., "Sistem Keamanan pada Ruang Pribadi Menggunakan Mikrokontroler Arduino dan SMS Gateway," *Jurnal Teknik dan Sistem Komputer* 1, no. 2 (2020): 126.

¹⁵Rut Dias Valentin et al., "Alat Uji Kadar Air Pada Buah Kakao Kering Berbasis Mikrokontroler Arduino," *Jurnal Teknik dan Sistem Komputer* 1, no. 1 (2020): 65.

¹⁶Hermawansyah Jauhari Arifin, Leni Natalia Zulita, "Perancangan Murottal Otomatis Menggunakan Mikrokontroler Arduino Mega 2560," *Jurnal Media Infotama* 12, no. 1 (2016): 91.

The use of Arduino IDE (Integrated Development Environment) software is an important step because this is where programs are created and uploaded using Arduino software, this aims to insert program code into Arduino. At this stage, the program code is also written to provide instructions using the C++ programming language which aims to run the system so that it can work according to the program code that has been loaded into an Arduino.¹⁷

Arduino IDE software consists of 3 (three) parts:

- a. Program editor, for writing and editing programs in processing languages. Listing programs on Arduino are called sketches.
- b. *Compiler*, a module that functions to change the processing language (program code) into binary code because binary code is the only programming language understood by the microcontroller.
- c. *Uploader*, a module that functions to enter binary code into the memory of the microcontroller.¹⁸

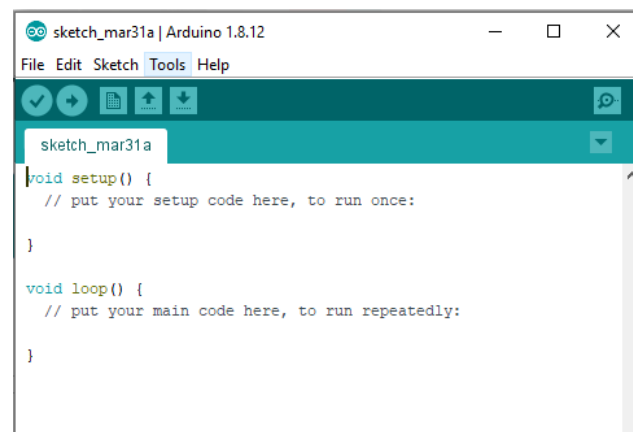


Figure 2: Software Arduino IDE (Integrated Development Environment)

C.2 Design and Manufacturing of Arduino-Based Rukyatul Hilal Instrument System

- a. Arduino-Based Rukyatul Hilal Instrument Components
 - 1) Arduino Mega 2560

¹⁷Muhtar Nurdiansyah et al., "Sistem Kendali Rotasi Matahari Pada Panel Surya Berbasis Arduino Uno," *Jurnal Teknik dan Sistem Komputer* 1, no. 2 (2020): 42.

¹⁸Jauhari Arifin, Leni Natalia Zulita, "Perancangan Murottal Otomatis Menggunakan Mikrokontroler Arduino Mega 2560." 91

Arduino Mega 2560 is a microcontroller on ATMEGA 2560 which has 54 digital inputs/outputs of which 16 pins are used as PWM outputs, 16 analog inputs, and inside there are 16 MHZ crystal oscillators, USB connections, power, ICSP, and reset buttons. This Arduino performance requires Microcontroller support by connecting it to a computer with a USB cable to turn it on using AC or DC current and it can also use a battery.¹⁹

2) Digital Compass Module GY-273 HMC5883L

This module is useful for accessing the cardinal directions or compass directions by using a combination of MEMS magnetometer sensors in the x, y, and z directions on the sensor to direct the robot towards the bearing angle and set it as the compass setpoint which is used for the robot navigation process.²⁰

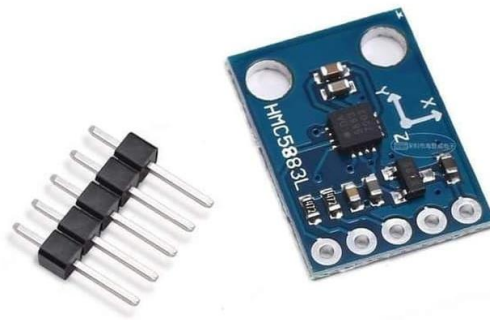


Figure 4: Digital Compass Module GY-273 HMC5883L

3) Servo Motor MG995

The MG995 servo motor is one type of actuator that is quite widely used in industrial or robotics systems. Servomechanism abbreviated as servo is a device used to provide mechanical control over a distance. Servo motor can control the position, can turn and maintain a position based on the reception of an electronic signal.²¹

¹⁹I. Oktariawan, M. Martinus, and S. Sugiyanto, "Pembuatan Sistem Otomasi Dispenser Menggunakan Mikrokontroler Arduino Mega 2560," *Jurnal Ilmiah Teknik Mesin Fema* 1, no. 2 (2013): 19.

²⁰Desmas A. Patriawan et al., "Uji Presisi dari Nonholonomic Mobile Robot Pada Rancang Bangun Sistem Navigasi," *Journal of Mechanical Engineering, Science, and Innovation* 1, no. 1 (2021): 31.

²¹Purwono Prasetyawan et al., "Pengendali Lengan Robot dengan Mikrokontroler Arduino Berbasis Smartphone," *Jurnal Teknik Elektro ITP* 7, no. 2 (2018): 105.



Figure 5: Servo motor MG995

4) LCD (Liquid Crystal Display)16x2

Liquid Crystal Display (LCD), is used to display characters in the form of good writing indicating the temperature, humidity and running system mode, in the LCD module there is a Microcontroller that functions as a controller for the LCD character display. Microcontroller on an LCD is equipped with memory and registers.²²

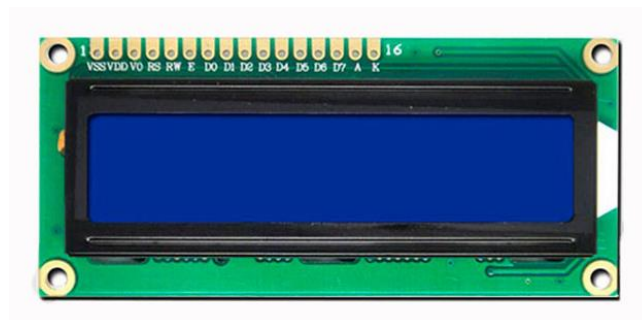


Figure 6: LCD (Liquid Crystal Display) 16x2

5) *Monocular Tele zoom.*

Monocular are binoculars to see the details of an object or objects that are far away with one eye. Because they use one eye, magnifying glasses and small telescopes are also monocular. However, monocular binoculars here are binoculars that do not rotate the object so that the object is seen in its actual

²²Tri Widodo et al., "Sistem Sirkulasi Air Pada Teknik Budidaya Bioflok Menggunakan Mikrokontroler Arduino UNO R3," *Jurnal Teknik Dan Sistem Komputer* 1, no. 2 (2020): 35.

position. In a way, monocular binoculars are small telescopes that are half the size of binocular binoculars.²³



Figure 7: Monocular Tele zoom

6) Tripod

A tripod is a support that has three legs and serves to support objects that are above it. Tripods are usually used in photography and videography, to support a camera that is above it. So as not to shake and can produce a focused image. The author uses a tripod as a support to avoid shaking when in use.



Figure 8: Tripod

7) Jumper Cable

Cable of jumper is an electrical cable to connect between components in the *bread board* without need *soldering iron*. Jumper cables generally have a connector or pin at each end. The connector for piercing is called *male connector*

²³Mybest, "10 Rekomendasi Teropong Monocular Terbaik (Terbaru Tahun 2021) | Mybest," accessed April 25, 2022, <https://my-best.id/137270>.

or often called male cable, and the connector to be pierced is called *female connector* or female cable.²⁴



Figure 9: Jumper Cable

8) Battery

Batteries are devices that can convert the chemical energy contained in the active ingredients of the battery components into electrical energy through electrochemical reduction and oxidation reactions. Reduction reactions are reactions of adding electrons and decreasing oxidation numbers, while oxidation reactions are reactions of losing electrons and adding oxidation numbers.²⁵ The author uses a battery type 9V or often referred to as a box battery because its shape is different from other batteries.



²⁴Sherwin R.U.A Sompie Theodorus S Kalengkongan, Dringhuzen J. Mamahit, "Rancang Bangun Alat Deteksi Kebisingan Berbasis Arduino Uno," *Jurnal Teknik Elektro dan Komputer* 7, no. 2 (2018): 185.

²⁵Aditya Satriady et al., "Pengaruh Luas Elektroda Terhadap Karakteristik Baterai Lifepo 4," *Jurnal Material dan Energi Indonesia* 06, no. 02 (2016): 43.

Figure 10: 9 V battery or box battery.

9) I2C (*Inter Integrated Circuit*)

I2C or commonly called Inter-integrated Circuit is used for faster communication between devices without losing data. I2C is liaison between components that function to send and receive data.²⁶



Figure 11: I2C (Inter-integrated Circuit)

10) Keypad

The keypad is *the* keys arranged in a matrix (row x column) so as to reduce the use of input pins. The keypad functions as a data input device.²⁷



Figure 12: Keypad

b. Electronic Architectural Design

Electronic architecture design is a discussion that describes the flow of relationships between several electronics and mechanics modules used.²⁸ To make it easier to design electronic architecture, the author uses fritzing. Fritzing is one of the best supporting open source software for Arduino. With help from Fritzing for

²⁶Shivani Mehrotra and Nisha Charaya, "Design and Implementation of I2C Single Master on Fpga Using Verilog" *IJRIT International Journal of Research in Information Technology* 3, no. 1 (2015): 1.

²⁷Helmi Guntoro, Yoyo Somantri and Erik Haritman "Rancang Bangun Magnetic Door Lock Menggunakan Keypad dan Solenoid Berbasis Mikrokontroler Arduino Uno" *Jurnal Electrans* 12, no. 1 (2013): 40.

²⁸Elin Gusbriana Rut Dias Valentin, Bintang Diwangkara, Jupriyadi, Sampurna Dadi Rskiono, "Alat Uji Kadar Air pada Buah Kakao Kering Berbasis Mikrokontroler Arduino," *Jurnal Itikom* 1, no. 1 (2020): 29.

experimental circuits, users can easily make wiring connections between electrical components in an electric breadboard, and complete their relative functional sketches for explanations and their PCB layout for later production.²⁹

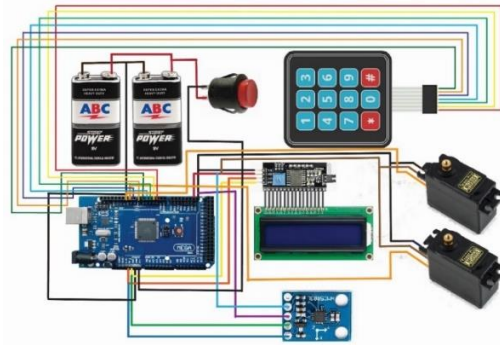


Figure 13: Electronic architectural design

c. Flow Diagram

Flowcharts are used to make it easier for programs to be created with special symbols that have their own meaning.³⁰ The author uses power that comes from the power supply or battery. After Arduino turns on automatically other components are active. Then the compass module will look for the north direction which is used as a benchmark to determine the azimuth of a celestial body. After the compass has succeeded in determining the desired north direction, the next step is to input the azimuth and altitude data of a celestial object that will be the object of observation. If the azimuth and altitude data have been inputted, without waiting for another command, the horizontal and vertical servo motors will rotate according to the data entered.

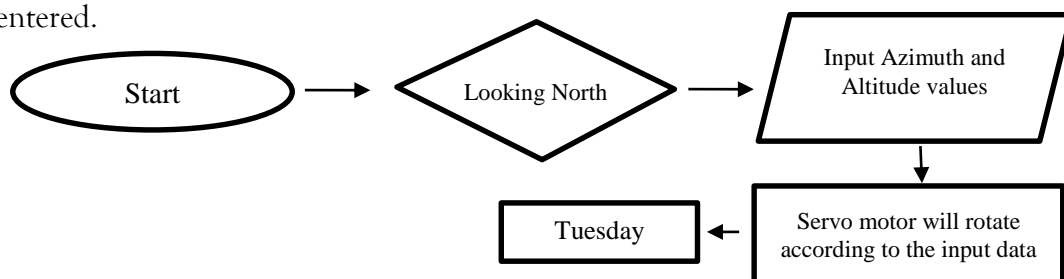


Figure 14: Flowchart

²⁹Ping-Sung Liao and Chein-Hua Lee, “Applying Open Source Softwares Fritzing and Arduino to Course Design of Embedded Systems,” *International Journal of Automation and Control Engineering* 4, no. 1 (2015): 41.

³⁰Agung Tri Wahyudi et al., “Sistem Otomatis Pemberian Air Minum Pada Ayam Pedaging Menggunakan Mikrokontroler Arduino,” *Jurnal Teknik dan Sistem Komputer* 1, no. 1 (2020): 17

d. Programming of Arduino-Based *Rukyatul Hilal* Instrument

All celestial bodies have a more specific address (coordinates) on the celestial map. It's the same as when someone visits the house of relatives and relatives, they might do one or two things, use the google maps application or choose to ask local residents for directions. Similarly, when searching for celestial objects. There are several types of coordinate systems, two of which are often used, namely the horizon coordinate system and the equatorial coordinate system. In this discussion, the author will discuss more specifically about the horizon coordinate system.

The horizon coordinate system is the simplest and easiest to understand coordinate system. However, the use of this coordinate system is very limited, it can only state the position of celestial bodies at one particular moment, for different times this coordinate system cannot provide an easy relationship with the previous position of celestial bodies. Due to the rotation of the earth, the coordinates of the horizon of a celestial body viewed from a place will always change at any time. The horizon coordinate system divides the globe into two parts, namely the upper part where the heavenly bodies can be seen and the lower part where the celestial bodies are not visible.³¹

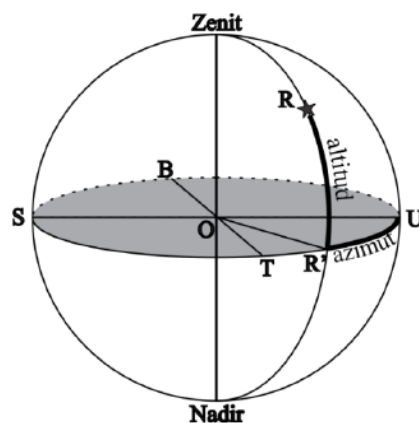


Figure 15: Horizon coordinate system

In order to make it easier to understand the coordinate system of the horizon, you must first understand the coordinates of the horizon coordinate system, namely azimuth

³¹Abu Yazid Raisal et al., "Posisi Matahari pada Saat Ekuinoks, Summer Solstice, dan Winter Solstice di Observatorium Ilmu Falak Universitas Muhammadiyah Sumatera Utara," *Jurnal Riset dan Kajian Pendidikan Fisika* 7, no. 1 (2020): 37.

and altitude. The azimuth of a star is the distance calculated from the north point to the vertical circle that the star travels through the horizon circle or horizon in a clockwise direction.³² The height of a celestial body can be described on the celestial sphere by making a large circle through the zenith, the celestial body is perpendicular to the horizon (vertical circle).

The altitude value is calculated from 0° (horizon) to 90° (zenith). At sunrise or sunset, the altitude angle value is 0°. The maximum value of the altitude angle is 90° when the sun is directly above the head. The azimuth angle of the sun is the angular position of the sun's projection on the horizon measured from the north of the earth in a clockwise direction. The azimuth angle value of the sun is 0° in the north, 90° in the east, 180° in the south, and 270° in the west.³³

This horizon coordinate system is applied in programming the Arduino-based *Rukyatul Hilal* Instrument. The working principle of this instrument is the same as the theodolite. Both of them use altitude and azimuth as their trajectory in observing a celestial object.

Some Arduino programming cases require additional libraries before they can be uploaded to Arduino. For example, the compass module which requires these additional libraries. Additional libraries can be installed via the Arduino application which is connected to the internet. By clicking Sketch > Include Library > Manage Libraries. After the Library Manager window appears, type the name of the library you are looking for in the Filter Your Search field. The system will automatically search according to the keywords entered. After finding the library you are looking for, the next step is to click the Install button. The list of additional libraries that the author uses include:

- 1) Adafruit *Sensor* master
- 2) ESP8266 Wi-Fi master
- 3) hmc8831 creative electronics
- 4) Liquid Crystal I2C 1.1.2

³²Slamet Hambali, *Ilmu Falak 1 Penentuan Awal Waktu Shalat & Arah Kiblat Seluruh Dunia* (Semarang: Pascasarjana IAIN Walisongo Semarang, 2011), 52..

³³Raisal et al., "Posisi Matahari Pada Saat Ekuinoks, Summer Solstice, Dan Winter Solstice Di Observatorium Ilmu Falak Universitas Muhammadiyah Sumatera Utara.", 37

- 5) Mecha QMC5883L master
- 6) Ms timer
- 7) Serial master software
- 8) time master
- 9) wire

After all the additional libraries above have been installed. The next step is to type the *Rukyatul Hilal* Instrument program on the Arduino software (IDE). The *Rukyatul Hilal* Instrument Program has also been equipped with a compass calibration program which aims to increase the accuracy of this instrument.



Figure 15: Arduino-based Rukyatul Hilal instrument seen from above.



Figure 16: Arduino-based *Rukyatul Hilal* instrument seen from the side.

The method of using the Arduino-based *Rukyatul Hilal* Instrument is as follows:

- 1) Make sure the surface of the ground or floor where the Arduino-based *Rukyatul Hilal* Instrument will stand is flat and not tilted.
- 2) Then build an Arduino-based *Rukyatul Hilal* Instrument and make sure the Arduino-based *Rukyatul Hilal* Instrument stands perfectly flat using a water pass and keep it away from metal objects.
- 3) The next step is to press the red power button.
- 4) After the Arduino-based *Rukyatul Hilal* Instrument is turned on, wait for the short tutorial process of the Arduino-based *Rukyatul Hilal* Instrument on the LCD screen until the words "Calibration Looking for..." appear.
- 5) The next step is to find the north point, by turning the neck of the Arduino-based *Rukyatul Hilal* Instrument on the protruding and black handle until the words "True North" appear on the LCD and press # to continue the next process.
- 6) Then input the Azimuth and Altitude data of the celestial body you want to observe by pressing the number keys on the keypad. Press # for Azimuth data and press * for altitude data. After that, the horizontal and vertical servo motors will rotate according to the data that has been inputted. However, there are several things that must be considered first, such as the servo motor used by the author can only rotate 180° and data that can be inputted can only be up to units of degrees, and the servo motor used by the author rotates counterclockwise, in other words the opposite of the Azimuth direction itself, namely in a clockwise direction (North-East-South-West). To deal with it all, the author uses the following provisions:
 - a) If the azimuth of a celestial body is 1° up to 180° then 180° - Az
 - b) If the azimuth of a celestial body is 181° up to 360° then 360° - Az
 - c) If the azimuth of a celestial body is 1° up to 180° then 180° - Alt
 - d) If the azimuth of a celestial body is 181° up to 360° then Alt remains

C.3 Arduino-Based *Rukyatul Hilal* Instrument Analysis

Testing the accuracy of the Arduino-based *Rukyatul Hilal* Instrument in determining true North, the author compared the results of the Arduino-based *Rukyatul Hilal* Instrument with

the Sun's shadow method using a special stick before and after *Zawwal* (culmination). Testing was carried out on June 25, 2020 in front of the author's own house. The author uses a crossbar as a measure of the deviation of the two methods, and the results of the test are the Arduino-based *Rukyatul Hilal* Instrument has a deviation of $2^{\circ}30'$ from the measurement results using the sun's shadow method using *istiwa'*.

The sun's shadow method is a fairly accurate method of determining true north. Because this method utilizes the stick shadow of the direct movement of the Sun. For this reason, the shadow method is used as a parameter of the Arduino-based *Rukyatul Hilal* Instrument in determining true north.



Figure 17: The results of the northern comparison of the Arduino-based *Rukyatul Hilal* Instrument and the Sun's shadow method using a special stick

The author also compares the Arduino-based *Rukyatul Hilal* Instrument with *Mizwala* in determining the true north direction. The reason the author uses *Mizwala* is because *Mizwala* is one of the modern and quite accurate tools/methods for measuring Qibla direction. *Mizwala* is a tool to check or measure the Qibla azimuth which is a modification of the special stick (sundial) which consists of several components such as a gnomon (shadowing stick), a level plane and a rotary dial plane.³⁴

³⁴Hosen Hosen and Ghafiruddin Ghafiruddin, "Akurasi Arah Kiblat Masjid Di Wilayah Kecamatan Pademawu Kabupaten Pamekasan Dengan Metode Mizwala Qibla Finder," *AL-IHKAM: Jurnal Hukum & Pranata Sosial* 13, no. 2 (2018): 369.

Before making observations, the writer calculates the *Mizwah* value from *Mizwala*, the author calculates 4 observation times, namely 10:20 WITA, 10:25 WITA, 10:30 WITA and 10:35 WITA on 12 July 2020 M.

The following is the difference between measuring true north using *Mizwala* and the Arduino-based *Rukyatul Hilal* Instrument:

Table 1. Difference between *Mizwala* and Arduino

Observation time	<i>Mizwah</i>	Difference with Arduino-based <i>Rukyatul Hilal</i> Instrument
10:20 WITA	228°16' 49"	2°30'
10:25 WITA	226°57' 23"	2°35'
10:30 WITA	225°32' 49"	2°32'
10:35 WITA	224°2' 49"	2°31'
Average value		2°32'



Figure 18: Comparison of true north measurements using *Mizwala* and Arduino-based *Rukyatul Hilal* Instruments

The new author also observed the young Moon or the old *Hilal* directly to test the Arduino-based *Rukyatul Hilal* Instrument on 1 Shawwal 1441 H to coincide with May 24, 2020 at Lalos Beach, Kab. Toli-toli, Prov. Central Sulawesi.

Table 2. 1st Observational Data Location

Latitude	1°7' LU
Longitude	120°46'48" BT
Height	4 masl
Observation hours	17:59:17 WITA
<i>Hilal</i> Azimuth	$360^\circ - 293^\circ 34' 39'' = 66^\circ 25' 21''$ (rounded to 66°)
<i>Hilal</i> Altitude	17°26'26"

The first observation made by the author is that the *Hilal* cannot be seen because it is blocked by thick clouds. Although the weather at that time was quite sunny, the *Hilal* was still behind the clouds.

Then the author made a second observation the next day, 2 Shawwal 1441 H / 25 May 2020 M in a different place, namely on the Kalangkangan beach, Kab. Toli-toli, Prov. Central Sulawesi.

Table 3. 2nd Observational Data Location

Place latitude	1°4'50" LU
Longitude of place	120°47'56" BT
height of place	5 masl
Observation hours	18:06 WITA
Azimuth of the Moon	$360 - 296^\circ 44' 31'' = 63^\circ 15' 29''$ (rounded to 63°)
Moon Altitude	27°23'13" (rounded to 27°)

In this observation, the Arduino-based *Rukyatul Hilal* Instrument succeeded in showing and verifying the position of the young crescent moon. And the author uses an adapter

mounted on an Arduino-based *Rukyatul Hilal* Instrument telescope connected to a smartphone to photograph the image of the young crescent moon.



Figure 19: Image of the young crescent moon seen from the Arduino-based *Rukyatul Hilal* Instrument

Then the author made a third observation in the same place to ensure the accuracy of the Arduino-based *Rukyatul Hilal* Instrument with the following data:

Table 4. 3rd Observational Data Location

Observation hours	18:27 WITA
Azimuth of the Moon	$360^\circ - 295^\circ 45' 14'' = 64^\circ 14' 46''$ (rounded to 64°)
Moon Altitude	$22^\circ 47' 59''$ (opens to 22°)

The results of the third observation were the same as the second time, namely the Arduino-based *Rukyatul Hilal* Instrument succeeded in showing and verifying the position of the young crescent moon.



Figure 20: Third Moon Observation on the Kalangkangan Beach.

Then the author made observations again in the same place with the following data:

Table 5. 4th Observational Data Location

Observation hours	18:27 WITA
Azimuth of the Moon	$360^\circ - 295^\circ 45' 14'' = 64^\circ 14' 46''$ (rounded to 64°)
Moon Altitude	$22^\circ 47' 59''$ (opens to 22°)



Figure 21: The fourth observation using the Arduino-based *Rukyatul Hilal* Instrument

In this fourth observation, the Arduino-based *Rukyatul Hilal* Instrument also succeeded in showing and verifying the position of the Moon.

Based on several observations made by the author above, there are several corrections that need to be considered, such as the position of the Moon as seen from the Arduino-based *Rukyatul Hilal* Instrument telescope, not in the middle of the telescope (centre) but sometimes on the top, side and bottom. This is because there is rounding in inputting data to be entered into the Arduino-based *Rukyatul Hilal* Instrument and in determining the north point requires another correction $2^\circ 32'$ (the average value of the difference between North *Mizwala* and the Arduino-based *Rukyatul Hilal* Instrument).

This correction is used because the compass module on the Arduino-based *Rukyatul Hilal* Instrument is slightly tilted according to the correction. In accordance with the Arduino-based *Rukyatul Hilal* Instrument testing with the Sun's shadow method using the *Istiwa'* stick in determining true north which the author has described above. The true north deviation can change if an object with metal content is on the Arduino-based *Rukyatul Hilal* Instrument. Because the compass module used is very sensitive.

Another factor that affects the position of the Moon that is not visible in the center of the telescope (center) is the servo motor used by the author, which can only rotate up to a unit of degree and rotates *counterclockwise*. Therefore, the author uses the provisions in inputting data on the *Rukyatul Hilal*-based Instrument. The Arduino-based *Rukyatul Hilal* instrument will be more accurate when using a servo motor that can rotate up to units of a second. Based on the above, the Arduino-based *Rukyatul Hilal* Instrument is considered quite accurate.

The author realizes that the Arduino-based *Rukyatul Hilal* Instrument is still far from perfect. However, apart from that, the authors consider that the Arduino-based *Rukyatul Hilal* Instrument can show the position of the Moon and verify the data used quite accurately, as evidenced by the sight of the Moon on the Arduino-based *Rukyatul Hilal* Instrument telescope and can also be photographed using a smartphone.

D. Conclusion

The Arduino-based *Rukyatul Hilal* instrument uses the Arduino Mega 2560 Microcontroller as a control center or as the brain of this instrument and its programming uses Arduino software, namely IDE (Integrated Development Environment) as a programming place. The programming language used is a development of the C++ language which is quite easy to understand compared to other programming languages. Assembling the Arduino-based *Rukyatul Hilal* Instrument, the author also uses an additional library to simplify the programming process. Based on 4 observations of the Moon, the Arduino-based *Rukyatul Hilal* Instrument can successfully show the position of the Moon and verify the data used by the author correctly and the author can also take a clear picture of the Moon using a smartphone. However, it should be noted that the position of the Moon when viewed from the Arduino-based *Rukyatul Hilal* Instrument telescope is not in the middle of the telescope, but sometimes at the bottom, side and top.

E. Bibliography

Abdul Rafid Fakhrun Gani Yul Ifda Tanjung Abdul Rasyid Fakhrun Gani, Aji Ibnu Khair, and Sidiq Muhammad Jaka Maulana Ilham. "Prototipe Sajadah Otomatis Arah Kiblat dengan Mikrokontroler Arduino." *Einstein (EJournal)* 10, No. 1 (2022).

Arief, Fahmi Fardiyani, and Tole Sutikno "Kompas Digital dengan Output Suara Berbasis Mikrokontroler At89s52" *Telkomnika Telecommunication, Computing, Electronics and*

Control 6, no. 1 (2008).

Arifin, Zainul. *Ilmu Falak Cara Menghitung dan Menentukan Arah Kiblat, Rashdul Kiblat, Awal Waktu Shalat, Kalender Penanggalan, Awal Bulan Qomariyah (Hisab Kontemporer)*. Yogyakarta: Lukita, 2012.

Genaldo, Rahmad, Tri Septyawan, Ade Surahman, and Purwono Prasetyawan. "Sistem Keamanan Pada Ruangan Pribadi Menggunakan Mikrokontroler Arduino dan Sms Gateway." *Jurnal Teknik dan Sistem Komputer* 1, No. 2 (2020).

Hafidhin, Muhammad Irfan, Adam Saputra, Yuri Ramanto, and Selamat Samsugi. "Alat Penjemuran Ikan Asin Berbasis Mikrokontroler Arduino Uno." *Jurnal Teknik dan Sistem Komputer* 1, No. 2 (2020).

Hosen, Hosen, and Ghafiruddin Ghafiruddin. "Akurasi Arah Kiblat Masjid di Wilayah Kecamatan Pademawu Kabupaten Pamekasan dengan Metode Mizwala Qibla Finder." *Al-Ihkam: Jurnal Hukum & Pranata Sosial* 13, No. 2 (2018).

Arifin, Jauhari, and Leni Natalia Zulita, Hermawansyah. "Perancangan Murottal Otomatis Menggunakan Mikrokontroller Arduino Mega 2560." *Jurnal Media Infotama* 12, No. 1 (2016).

Junaidi and Yuliyah Dwi Prabowo. *Project Sistem Kendali Elektronik Berbasis Arduino*. Bandar Lampung: Anugrah Utama Raharja, 2013.

Liao, Ping-Sung, and Chein-Hua Lee. "Applying Open Source Softwares Fritzing and Arduino to Course Design of Embedded Systems." *International Journal of Automation and Control Engineering* 4, No. 1 (2015).

Miptahudin, R. Apip, and M. Aris Risnandar. "Uji Koreksi Arah Kiblat di Masjid Gedhe Kauman Yogyakarta Menggunakan Kompas Digital dan Mikrokontroler Arduino." *Al-Jazari: Journal Mechanical Engineering* 3, No. 2 (2018)

Mybest. "10 Rekomendasi Teropong Monocular Terbaik (Terbaru Tahun 2021) | Mybest." Accessed April 25, 2022. <https://my-best.id/137270>.

Nurdiansyah, Muhtar, Erick Chomper Sinurat, Muhammad Bakri, and Imam Ahmad. "Sistem Kendali Rotasi Matahari pada Panel Surya Berbasis Arduino Uno." *Jurnal Teknik dan Sistem Komputer* 1, No. 2 (2020).

Oktariawan, I., M. Martinus, and S. Sugiyanto. "Pembuatan Sistem Otomasi Dispenser Menggunakan Mikrokontroler Arduino Mega 2560." *Jurnal Ilmiah Teknik Mesin Fema* 1, No. 2 (2013).

Patriawan, Desmas A., Bagoes P. Natakusuma, Ahmad Anas Arifin, Hasan S. Maulana, Hery Irawan, and Bambang Setyono. "Uji Presisi dari Nonholonomic Mobile Robot pada Rancang Bangun Sistem Navigasi." *Journal of Mechanical Engineering, Science, and Innovation* 1, No. 1 (2021).

Prasetyawan, Purwono, Yopan Ferdianto, Syaiful Ahdan, and Fika Trisnawati. "Pengendali Lengan Robot dengan Mikrokontroler Arduino Berbasis Smartphone." *Jurnal Teknik Elektro Itp* 7, No. 2 (2018).

- Qulub, Siti Tatmainul. *Ilmu Falak dari Sejarah ke Teori dan Aplikasi*. Depok: Rajawali Pers, 2017.
- Raisal, Abu Yazid, Hariyadi Putraga, Muhammad Hidayat, and Rizkiyan Hadi. "Posisi Matahari pada Saat Ekuinoks, Summer Solstice, dan Winter Solstice di Observatorium Ilmu Falak Universitas Muhammadiyah Sumatera Utara." *Jurnal Riset dan Kajian Pendidikan Fisika* 7, No. 1 (2020).
- Royhan, Muhamad. "Pengukuran Tegangan Baterai Mobil dengan Arduino Uno." *Jurnal Teknik Informatika Unis Jutis* 6, No. 1 (2018).
- Valentin, Rut Dias, Bintang Diwangkara, Jupriyadi, Sampurna Dadi Rskiono, and Elin Gusbriana. "Alat Uji Kadar Air pada Buah Kakao Kering Berbasis Mikrokontroler Arduino." *Jurnal Jtikom* 1, No. 1 (2020).
- Satriady, Aditya, Wahyu Alamsyah, H I Saad, and Sahrul Hidayat. "Pengaruh Luas Elektroda Terhadap Karakteristik Baterai Lifepo 4." *Jurnal Material dan Energi Indonesia* 06, No. 02 (2016).
- Shivani Mehrotra, and Nisha Charaya. "Design and Implementation of I2c Single Master on Fpga Using Verilog" 3, No. 1 (2015).
- Slamet Hambali. *Ilmu Falak 1 Penentuan Awal Waktu Shalat & Arah Kiblat Seluruh Dunia*. Semarang: Pascasarjana IAIN Walisongo Semarang, 2011.
- Smith, Alan G. *Introduction to Arduino: A Piece of Cake!* California: Create Space, 2011.
- Guntoro, Helmi and Yoyo Somantri. "Rancang Bangun Magnetic Door Lock Menggunakan Keypad dan Solenoid Berbasis Mikrokontroler Arduino Uno" *Electrans Jurnal Teknik Elektro, Komputer dan Informatika*, 12, No. 1 (2013).
- Kalengkongan, Theodorus S., Dringhuzen J. Mamahit, and Sherwin R.U.A Sompie. "Rancang Bangun Alat Deteksi Kebisingan Berbasis Arduino Uno." *Jurnal Teknik Elektro dan Komputer* 7, No. 2 (2018).
- Valentin, Rut Dias, Bintang Diwangkara, Jupriyadi Jupriyadi, and Sampurna Dadi Riskiono. "Alat Uji Kadar Air pada Buah Kakao Kering Berbasis Mikrokontroler Arduino." *Jurnal Teknik dan Sistem Komputer* 1, No. 1 (2020).
- Wahyudi, Agung Tri, Yoga Wahyu Utama, Muhammad Bakri, and Sampurna Dadi Rizkiono. "Sistem Otomatis Pemberian Air Minum pada Ayam Pedaging Menggunakan Mikrokontroller Arduino dan Rtc Ds1302." *Jurnal Teknik dan Sistem Komputer* 1, No. 1 (2020).
- Widodo, Tri, Bambang Irawan, Agung Tri Prastowo, and Ade Surahman. "Sistem Sirkulasi Air pada Teknik Budidaya Bioflok Menggunakan Mikrokontroler Arduino Uno R3." *Jurnal Teknik dan Sistem Komputer* 1, No. 2 (2020).
- Zainuddin, Aziz, Akhmad Hendriawan, and Hary Oktavianto. "Kompas Digital Penunjuk Arah Kiblat dengan Output Visual," article <https://www.pens.ac.id/2013/05/02/20130813144934-1416/>.