The Determination of Dawn Time in Medan Using SQM with Raspberry Pi Based

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Abstract: *The beginning of dawn prayer is still a hot debate among Falak practitioners and astronomers in Indonesia. The Adzan marks the start of dawn prayer time were too fast because the sky is still dark and not as mentioned in the Hadith, which is when the sky gets brighter. This study aims to prove the change from the night sky to the bright sky using a photometer called SQM with a recording device based on Raspberry Pi so that it can be used easily, quickly, lightly, and also safe to be left in a location during the data collection process. The results obtained in this study show that SQM on Raspberry can function properly, the dawn time at SQM readings using Raspberry Pi shows that the Sun is in the dip range of 15-18 degrees below the horizon when the sky changes brighter occurred.*

Keywords: *Dawn, SQM, Raspberry, Prayer Time*

Introduction

The beginning of dawn time has the faintest entry sign compared to the other prayer time. The difficulty in seeing the early signs of dawn time becomes higher with the advancement of civilization and the brighter night sky. Therefore, Muslims are looking for ways to find the starting time by making prayer times schedules based on previous observations and following the schedules in Islamic countries (Herdiwijaya, 2017).

In Indonesia, the ijtihad used is the position of the sun 20 degrees below the horizon, with the syar'i and astronomical foundation that are considered strong, because the Indonesia territory is crossed by the Equator with a latitude closer to the Equator and has a thicker atmosphere (tropospheric thickness at low latitudes around ± 17 km), then the dawn time criterion used the sun's depth at 20° below the horizon. These criteria are now used by the Ministry of Religion, Republic Indonesia until reliable and convincing research by observations is done (Zaman, 2018).

The dawn time study is continuing, either using direct visual observation, remote sensing, remote collective, image-taking instruments, and non-imagery instruments such as Sky Quality Meter (SQM), manually or with an automation system. The technology's existence also ensures the beginning of dawn time that is following the criteria in the Hadith, celestial phenomena that occur when the day and night change occur more accurately. With the limitations of human abilities, the existence of instruments with the same arrangement can be implemented by anyone. It can be the standard Procedure for joint studies and research that can be repeated and developed on the same basis and tools. The processing method can also be carried out with the same process so that comparisons between locations and each instrument can be carried out to achieve

the best conclusion. The data obtained from these instruments can be presented with a graph so that it can show the time of transition from dark to light (Putraga et al., 2022).

Early dawn experiments using simulations from planetarium software called Stellarium. Stellarium is software that can be used to demonstrate the movement of celestial bodies and celestial phenomena that occur when the time, location, and conditions are determined by the user (Putraga & Setiawan, 2018). With the position of the sun at depth of 20°, Stellarium does not show any changes in the night sky that can be seen by the eye visually. The beginning of dawn time with a sun depth of 20 ° is also still not felt to be able to see the change in the color of the sky from night to a morning or entering the beginning of dawn time through direct visual observation by researchers.

The difference was also found in the initial determination of the time for the dawn prayer of majlis tarjih and tajdid Muhammadiyah in December 2020 with the National conference which was also tanfidz in march 2021, correcting the height of the dawn sun which was originally -20° corrected to 18° below the horizon. The consequence of this decision was that the dawn time for Muhammadiyah was delayed to 8 minutes from the dawn time schedule set by the ministry of religion (Cahyani, 2021).

Previous studies found that the brightness level of the night sky at OIF UMSU Medan was already on the Bortle grade 6 scale, which means it is at the urban level (Butar-Butar et al., 2022). The dawn time at the urban level shows more difficulty to be seen because of many artificial lights affecting the sky and the observer's eyes to find the phenomenon becomes more difficult. And the dawn time study in OIF UMSU Medan with SQM directed to Zenith and Moving Average Approach show that the dawn time is at 11,07°(Rakhmadi et al., 2020). Related to the problem above, the author wants to study the problem of dawn time determination reviewed from data retrieval through Raspberry Pi-based SQM.

Literature Review

1. Dawn and Twilight

Dawn time is defined as the time that begins before sunrise on the horizon which signifies the change of the dark sky to light. The process of scattering light in the atmosphere causes colors at dusk to be visible ranging from yellow, orange, purple, and reddish to dark red. The physical appearance of dawn is not as easy to see and feel as the sunrise phenomenon, although everything is also influenced by the conditions or density of the Earth's atmosphere.

The beginning of dawn is more difficult to understand because of the dark atmosphere and the insensitive of the eye to see the changes in light intensity and dim color changes, so it requires instruments to measure the scattering of light and its color, both natural light sources and light pollution (artificial light), due to the layer structure and inhomogeneous composition of the atmosphere (Herdiwijaya, 2017).

Astronomical twilight happened when the Sun is at a depth/elevation of 12 – 18 degrees below the horizon (z=108°) from the geometric center (Rahmadani & Putraga, 2020). The sky is dark and starting to go bright, the outer objects around us are starting to be distinguishable when the eye adapts long enough in the dark without the scattering of sunlight in the sky. The natural signs of the dawn are the brightness that appears to spread across the horizon with bright color. The light continued to grow until the sun finally rose.

Some Islamic societies have differences in setting the depth of the sun without a clear scientific explanation of the dawn of shadiq. The Indonesian represented by the Ministry of Religious Affairs sets the sun's height at 20º below the horizon in determining the beginning of the dawn prayer time and 18º for the isya time. While the Muhammadiyah organization sets the Dawn time when the sun is about 18º below the horizon (or the zenith distance of the sun = 108º).

2. Sky Quality Meter

Sky Quality Meter (SQM) is an instrument with a FOV of 20 degrees, it has a relative error of less than 3% (Herdiwijaya, 2017). SQM is a semiconductor-based device that is capable to convert photons or light particles into electrical signals. The number of photons captured from the sky determines the value of the degree of brightness of the sky expressed in magnitude per *arc second square or magnitude per second arc squared*. The higher the value, the darker the sky conditions. So the value indicated by SQM will be at a constant value and then decrease further until it goes to zero when the measurement is carried out from night to morning or vice versa (Pramudya & Raisal, 2017). The light pollution stage can be known by measuring the brightness level of the night sky using Sky Quality Meter (SQM). The night sky brightness is influenced by several factors, namely light from galaxies, zodiac lights, auroras, night airglows, and twilight emission lines (Hassan et al., 2014).

The SQM spectral response is in a fairly wide range, namely the visual range of 400 – 650 nm for a 0.5 transmission with a peak of about 540 nm. Thus the spectral range of SQM corresponds to the spectral sensitivity of the human eye. Lightweight physical dimensions and ease of high-resolution data acquisition open up opportunities for wider SQM utilization with high mobility to determine dawn prayer times (Herdiwijaya, 2017).

SQM-LU are the types that are used, and LU stands for Lens and USB connection. They are the standard tools used to measure sky darkness. They are very easy to use. A sensor is a small black box that is portable and battery-powered. The SQM differs from the SQM-LU by the presence of a lens that narrows the field of view of the sensor. In all cases sensors are intercalibrated by the firm and values can be compared without the need for normalization. These products of Unihedron firm are the standard de facto for fixed position analysis. They all need a pc to work and this means that there is also the need for a power source. They can be used to monitor the trend of night darkness. They do this task very well, but they are lacking in usability. The need for a computer makes the system complex for field observations, furthermore, there are not so many programs available that can operate with these types of sensors. Using a laptop in the field pollutes the surroundings with the screen light. The usability drawback of these sensors is that there is not an LCD integrated into the sensor. The only way to know the sky luminosity during a measurement is to send a command through the pc and then read the result on the computer screen.

3. Raspberry Pi device

The Raspberry Pi is a single-board circuit (SBC) which is the size of a credit card that can be used to run office programs, computer games, and as a media player for high-resolution videos. Raspberry Pi was developed by a non-profit foundation, the Rasberry Pi Foundation, which was led by some developers and computer experts from the University of Cambridge, UK.

The Raspberry Pi is intended as an educational tool to encourage children to experiment with computers. The device is pre-installed with interpreters and compilers for various programming languages. For beginners has been provided Scratch, a graphic-based programming language from MIT. We can write programs for Raspberry Pi in different languages such as C, Ruby, Java, Python, and Perl. The Raspberry Pi distinguishes itself from computers in general not only in terms of price and size but also because of its ability to integrate with electronic projects (Pribadi et al., 2019).

Method

This study was conducted by collecting night sky data reading from SQM throughout the night until near sunrise, then processed with a mathematical approach using Ms. Excel and the Moving Average approach in making decisions to determine the beginning of dawn time. Data collection was carried out at the Falak Science Observatory University of Muhammadiyah North

Sumatra located in Medan City, North Sumatra. SQM is activated throughout the night daily. The data used in this study used the criteria of the absence of the moon throughout the night before dawn or the moon was in the 0-50% phase only. As for the methods carried out using the Raspberry Pi device, they are as figure 1 follows:

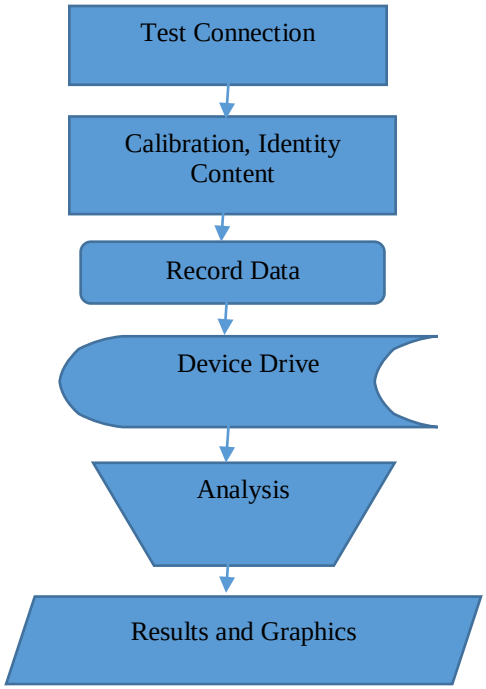

Figure 1. SQM Raspberry operation flowchart

The first stage is connecting the SQM photometer to the Raspberry Pi device and retrieving several measurement tests (information, calibration, and data). Checking that the instrument is working according to purpose. Calibrating the SQM to be capable of reading the sky to convert into real data in each iteration of the program to make sure to read the dark (nighttime) or Brightness (Daytime). SQM program will be stored in two different files (file.dat and graphic). Commands are executed via the command line in the terminal environment in raspberry based on *pi@raspberry:~$*. Furthermore, scratching the observation location and local time-to-time settings to adjust the timestamp of data reading.

The technical analysis used is the Moving Average approach which shows the average value over a set period, in which the averaged data is time-dependent data. The determination of the beginning of dawn time is seen from the results of the analysis of the MA approach which produces sustainable positive values.

Result and Discussion

Data retrieval uses the interval that has been set in the command input and the settings of the program used. Furthermore, data selection and reduction are carried out to get the best results according to the collection time range between 04.00 a.m. and sunrise.

The result is a data logger or data set at a certain time, a graph of the value of the SQM reading against the time according to the data logger, and the estimated beginning of dawn time based on the specified solar dip. Furthermore, the data is carried out in an analysis process using the MA method in Microsoft Excel software to obtain the value point of the change in sky

brightness. Furthermore, the data is processed into graphs or plots and then examines between the results of the table and the results of the plot or graph to see the beginning of the change in the dawn sky as shown in Figure 2.

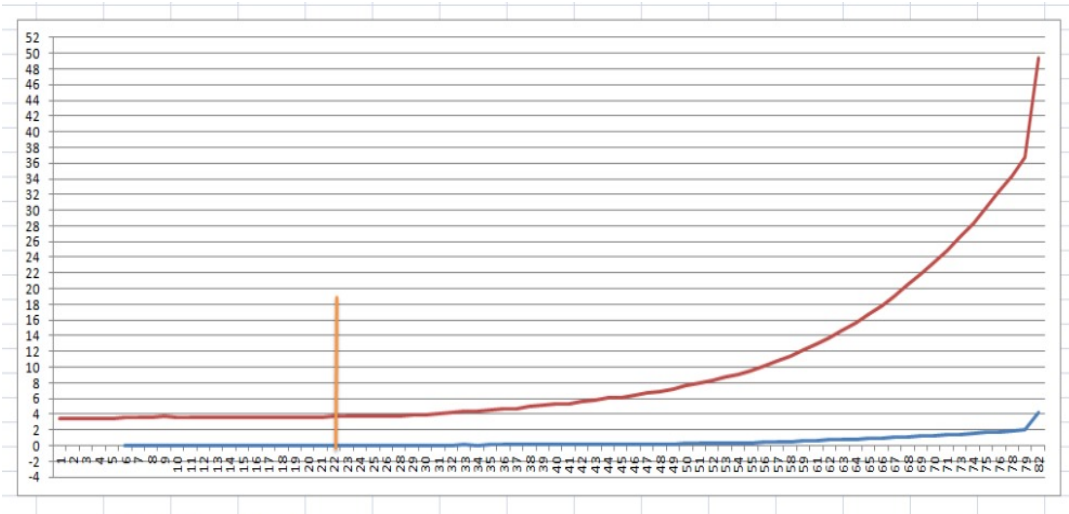

Figure 2. Plotted SQM data in Ms. Excel

The data retrieving using raspberry pi-based SQM gave the initial results of dawn time at almost the same point as the results on the processing of the Moving Average approach, the graph produced by raspberry-based SQM is shown in Figure 3. The graph generated by raspberry pi started from the evening hour to dawn, so the writer cropped the graph for the night on a new day or from 00.00 A.m. to 07.00 A.m. to observe the dawn time.

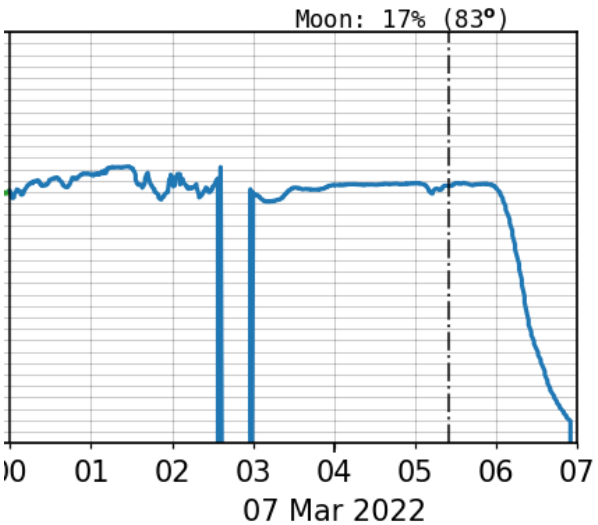

Figure 3. Results of early dawn time observations on Raspberry-based SQM

Based on the MA method approach, it was found that the change in the color of the sky was on March 7, 2022, indicating that the initial change in dawn time started at 05:29:30 WIB with the sun's altitude at that time being at an elevation of -16° 55' 40". From the results of this study, a difference of 3° 04 ' 20 " or 12 minutes longer than the dawn time was obtained based on the criteria of the Ministry of Religion which used dip -20° as the beginning of dawn time at 05:17 WIB for the Medan City area, North Sumatra.

The Processed data is shown in table 1 below.

Date	Dawn Time on Raspberry Pi-based SQM	Dawn Time on Moving Average
Nov 5th, 2021	-17° 30’	-14° 20’
Nov 6th, 2021	-17° 20’	-15° 00’
Jan 07th, 2022	-18° 00’	-17° 41’
Jan 08th, 2022	-17° 32’	-16° 23’
Mar 03rd, 2022	-17° 25’	- 13° 00’
Mar 04th, 2022	-17° 31’	-16° 20’
Jun 30th, 2022	-17° 35’	-14° 16’
Jul 01st, 2022	-17° 20’	-15° 27’
Aug 04th, 2022	-17° 31’	-15° 02’
Aug 05th, 2022	-17° 32’	-13° 57’
Sep 02nd, 2022	-17° 28’	-13° 22’
Sep 03rd, 2022	-17° 29’	-14° 03’
Average	-17° 31’	-14° 54’

The preliminary results of dawn time using Raspberry-based SQM with the absence of the moon in the night sky as shown in figure 4.

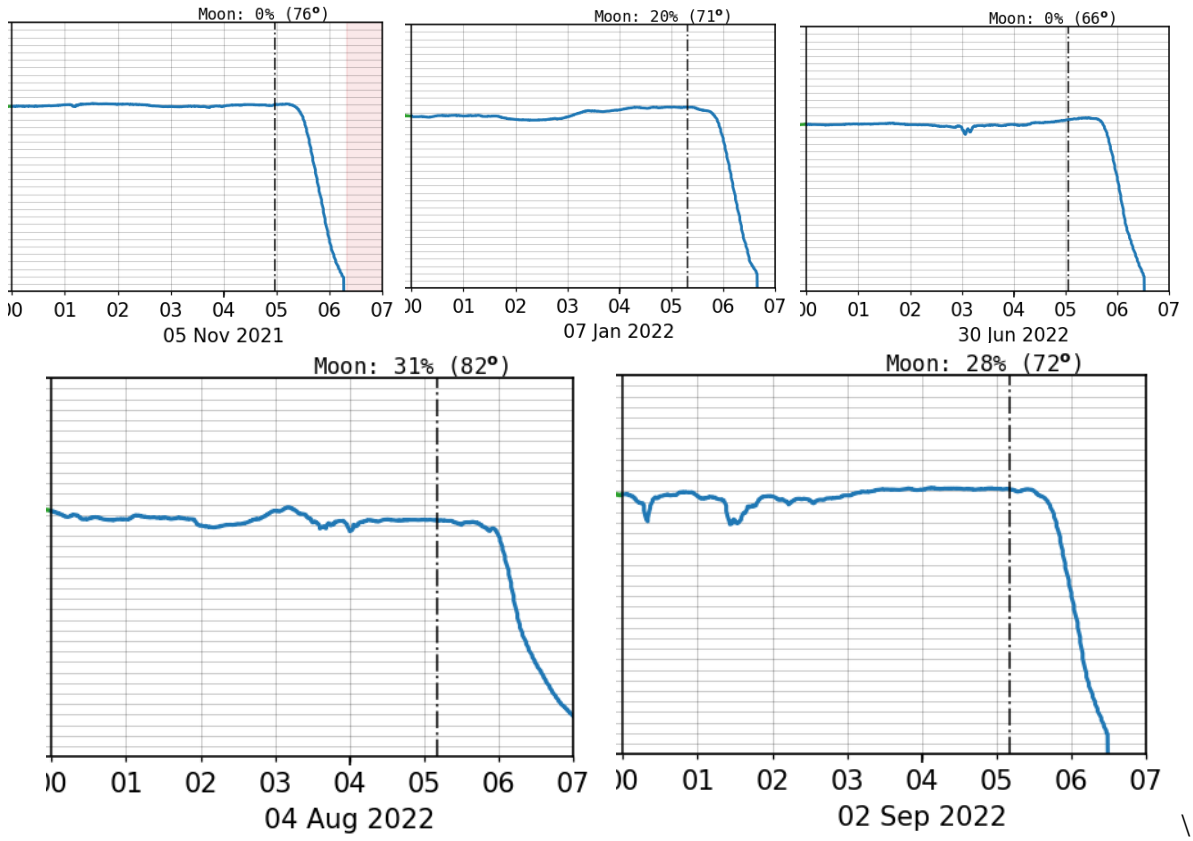

Figure 4. Some Results of early dawn time observations on Raspberry-based SQM with the absence of the Moon in the Nighttime

Based on this trial, the raspberry pi is capable to integrate SQM for data retrieval and recording. The problem that rises is sometimes the raspberry cant read the SQM, as shown in figure 3, there is error data that the sqm read from 2.30 A.m to 03.00 A.m so the raspberry record it as 0 to make the logger continue the reading. And when the electricity is down, the SQM also stops working, there is an improvement needed for 24-hour data logging.

Conclusion

The results from using Raspberry Pi-based SQM data collection show that the beginning of dawn time is at a depth ranging from 16° - 17° below the horizon or 12-16 minutes after the beginning of dawn time on the criteria of the Ministry of Religion. Processing using the proximity of the MA method also obtained the determination of the cut-off of the graph starting from the graph data showing almost the same value as the processed results of raspberry-based SQM. The Raspberry device shortens the observation time in charting and draws the initial conclusion of the dawn time that occurs based on the recording of night sky data. The problem that occurs is some blank readers need stable electricity to keep raspberry pi working better.

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