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The Determination of Dawn Time through Image Processing Camera

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Abstract

Determining the early time prayer is very fundamental for Muslims as it directly relates to the legal requirements of prayer. Prayers are not performed whenever we want, but rather there is a determination of the beginning and end of the prayer time as a guideline for Muslims to carry it out. The Indonesia government sets standards for Muslims to perform the dawn prayer service, by precisely determining the degree of the emergence of the dawn of *Sadiq* by -20^0. This study aims to compare the determination of the government's dawn time using different sensors, specifically drone cameras as image sensors. Drones were chosen due to their several advantages. The data generated by the drone is in the form of photos, which are subsequently processed using digital image processing software, called image-J. The data obtained are in the form of mean and standard deviation. All data collected in 1 day is recorded using Excel to form a graph of data which is then carried out by a polynomial approach to find out the cutoff point as the beginning of the dawn of *Sadiq* which indicates the start of dawn. The method used in this research is using the 4th order polynomial approach and the *Sarrus* method and the data obtained is the mean value and standard deviation. The conclusions obtained in the image analysis research are that the government's dawn time is 15 minutes too fast, the standard obtained in this study is -14.98° and unlike 2D SQM data, 3D drone data results in more accurate data analysis.

Keywords: Cut – Off Point; Dawn of Sadiq; Drone Camera; Early Time Prayer; Image Sensor.

Introduction

The determination of the early time for prayer is a fundamental rule in Islam since it is related to the legal requirements of prayer. Prayer is not performed at any time according to our wishes. Instead, there is a determination of the starting time and the ending of prayer time as a guide for Muslims to carry it out [1]. In conducting the early prayer time, Islamic scholars have been reluctant not to make a dichotomy between the sharia and scientific perspectives. The message conveyed in *Surah An-Nisa* 103 of the Quran is as follows.

فَاِذَا قَضَيْتُمُ الصَّلٰوةَ فَاذْكُرُوا اللّٰهَ قِيَامًا وَّقُعُوْدًا وَّعَلٰى جُنُوْبِكُمْۚ فَاِذَا اطْمَأْنَنْتُمْ فَاَقِيْمُوا الصَّلٰوةَۚ اِنَّ الصَّلٰوةَ كَانَتْ عَلَى الْمُؤْمِنِيْنَ كِتٰبًا مَّوْقُوْتًا

Translation: "*And when you have completed the prayer, remember Allah standing, sitting, or [lying] on your sides. But when you become secure, re-establish [regular] prayer. Indeed, prayer has been decreed upon the believers a decree of specified times.*"

Nash refers to revelation of God or text in Al Quran which was directly received by the prophet Muhammad and the hadith of the Prophet Muhammad. *Nash* serves as a guide for humans and the anvil to carry out the scientific

observation on the determination of the early time prayer. However, it is based on the position of the sun and is the main factor causing the difference between space and time, leading to different times of prayer.

The Indonesia government sets the early prayer time, especially the beginning of the dawn prayer time, as this time is of utmost importance and challenging to discern only via visual observation. The indication starts at the time of dawn prayer, this is when the dawn of *Sadiq* or *Fajr Sadiq* (actual dawn) ends and ends until the sun rises. The sun position at dawn is below the true horizon (marked with a minus sign) with a certain height value.

Therefore, there is a standard imposed by the government, which is -20^0 below the eastern horizon. The standard was obtained by the government team, known as the *Rukyah* Reckoning Agency with one of the members being Prof. Thomas Djamaluddin who is an astronomer. The data collection was carried out in Labuan Bajo, Indonesia using a non-image sensor called the Sky Quality Meter (SQM) [2]. Referring to Al-Quran, *Surah Al-Baqarah* 187:

... وَكُلُوْا وَاشْرَبُوْا حَتّٰى يَتَبَيَّنَ لَكُمُ الْخَيْطُ الْاَبْيَضُ مِنَ الْخَيْطِ الْاَسْوَدِ مِنَ الْفَجْرِۖ ....

Translation:
....., And eat and drink until the white thread of dawn becomes distinct to you from the black thread [of night]. Then complete the fast until the sunset. ....

with other verse, *Surah At – Tur* verse 49,

وَمِنَ الَّيْلِ فَسَبِّحْهُ وَاِدْبَارَ النُّجُوْمِ

meaning:
And in a part of the night exalt Him and after [the setting of] the stars.

Referring to *Surah At – Takwir* (81) verse 18,

وَالصُّبْحِ اِذَا تَنَفَّسَۙ

meaning:
And by the dawn when it breathes

There has been much debate about the standards provided by the government, and even several institutions and academics have conducted studies and research related to these dawn standards in different places using different sensors for improving the quality of worship.

There are two types of sensors that can be used to determine the start of the dawn prayer time, namely image and non-image sensors. Image sensors are sensors that produce images or photos as output, while non-image sensors are sensors that produce numbers as output [3]. To determine the start of dawn, the government through the *Rukyah* Reckoning Agency, Ministry of Religion – The Republic of Indonesia uses a non-image sensor in the form of a SQM, which according to the explanation above, non-image sensors are only in the form of numbers and in general cannot be understood by the general public [4].

The time of dawn prayer holds significant importance for Muslims, and determining the right time to start the morning prayer service is an obligation in Islam. Traditionally, the time for the morning prayer is determined based on the observation of the sun and the position of dawn. However, these observations can be affected by weather and geographic conditions. Hence, the results are not always accurate. Therefore, this study aims to use the camera in image processing to detect the exact moment when dawn occurs, and thus determine the time of the morning prayer more accurately.

The drone camera is a one of image sensors that is the results of technological developments, especially in technology for taking photo and video [5]. The beginning of the drone concept was founded in 1849 until now, then the drones have undergone many changes both in function and in the form of the drone itself [6]. Researchers see a potential by implementing image sensors that can be carried out by drones to monitor the presence of the *Fajr Sadiq*. It can be developed to add the references as government considerations related to standards that have been set and improve the quality of Muslim prayer services.

This study aims to implement an image processing system using a camera to detect dawn and determine the time of dawn prayer accurately. By utilizing image processing technology, it is expected that this research can provide

more precise information regarding the start time of the morning prayer, and reduce potential inaccuracies caused by weather or geographical conditions.

Method

The research process can be seen in **Figure 1** starting from digital image processing literature, then taking photo data from a camera carried by a drone. Data collection was carried out for 30 days, accompanied by cropping of images that were considered to be noise or unwanted disturbances.

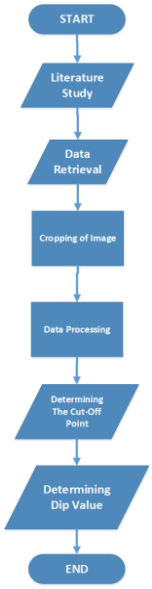


Figure 1. Research flowchart

The process of removing noise from photos is done by using the image-J software application. In this application, it is obtained from the average value and standard deviation that can be created as a graph by approximating it with a polynomial equation. It is created in order to determine the cut-off point as the initial determinant of entering dawn.

The noise cutting process is carried out using the Photoshop application on each photo obtained, because these results affect the data processing. Photoshop software is used because the cutting process can be done quickly through the feature of selecting multiple image pieces at one time. The Photoshop display process can be seen in **Figure 2**.

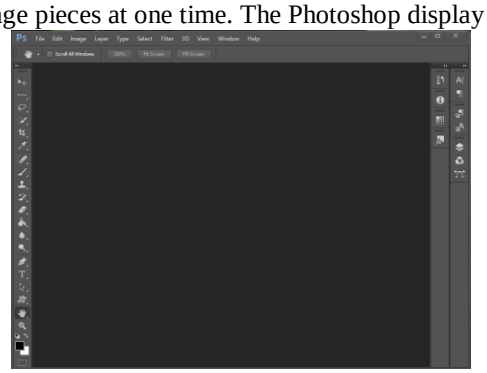


Figure 2. The display of Photoshop software.

The data collection process is taken by a drone camera, with the specifications as shown in **Table 1**.

Table 1. Data retrieval limitations.

No	Variables	Remark
1	Location	District of Citayam, Municipal of Bogor, Province of West Java, INDONESIA.
2	Latitude	$-06{,}453^0$
3	Longitude	$106{,}787^0$
4	Altitude	30 meter

The research method used in this study involves installing cameras in strategic locations to observe the sky and horizon before sunrise. The image taken is processed using image processing techniques to identify the moment when

the dawn light appears which indicates the time of the morning prayer. Edge detection, image segmentation, and color analysis algorithms are used to process image data and obtain information about the time of dawn.

A. Noise Cutting

The data processing stage begins with cutting photos that are considered noise or light caused by unwanted light such as house lights, street lights and other light that is caught by the receiving camera. Image cropping is done using Photoshop which provide the camera raw preferences feature as shown in **Figure 3** [7].

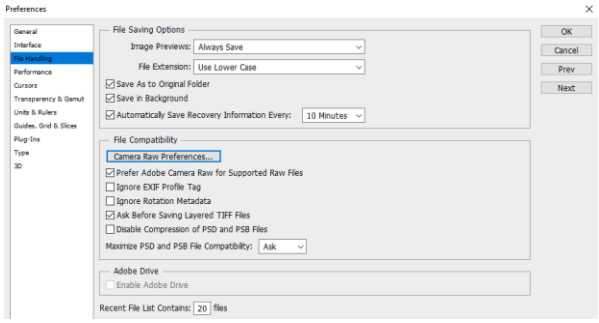


Figure 3. Display setting of raw camera.

By selecting camera raw preferences, a feature will be displayed, as shown in **Figure 4**. Arrangements are made according to our storage needs up to the photo format. This section illustrates the use of the use of photo format with the JPEG extension [8].

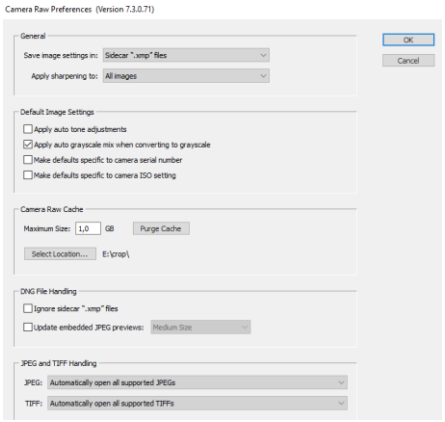
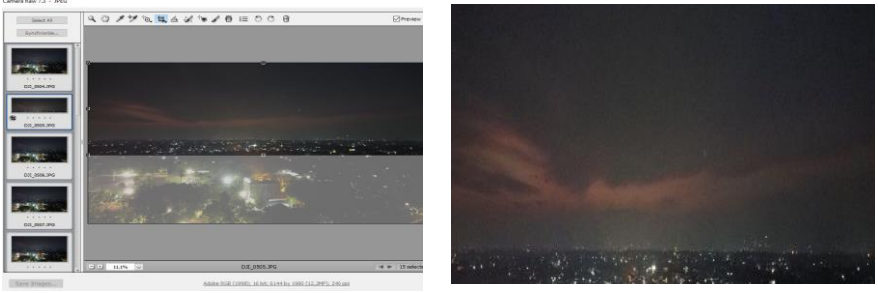


Figure 4. Advance of display setting of raw cameras.

The process of removing the light disturbances through the image–J software is conducted by choosing the file with the "open" button. Entering all the photos to be cropped, then to set the photo with the same size as shown in **Figure 5**. The photos created by the drone cannot be directly processed using image–J software caused many parts of the photos have a lot of image disturbances with instance of unwanted light. It must be removed by using the Photoshop, so as to get the maximum results [9].

Figure 5 (a) is the result of uncropped image data accompanied by unwanted lights [8]. This light can interfere the data processing in producing the image histogram display [8, 9]. **Figure 5 (b)** is a photo that exhibits less interference, resulting in a clearer image interference. It does not affect the results of data processing [7, 9].



(a) (b)

Figure 5. The set-up display of cropping photo (a). Before cropping, (b) After cropping.

B. Approximation of N – Order Polynomial Equation

To create an n^{th} order polynomial equation [10], it is formed from several equation as shown in Equation 1 to 5.

$$na_0 + \left(\sum x_i\right)a_1 + \left(\sum x_i^2\right)a_{2+}\left(\sum x_i^3\right)a_3 + \left(\sum x_i^4\right)a_4 = \sum y_i \quad (1)$$

$$\left(\sum x_i\right)a_0 + \left(\sum x_i^2\right)a_1 + \left(\sum x_i^3\right)a_2 + \left(\sum x_i^4\right)a_3 + \left(\sum x_i^5\right)a_4 = \sum x_i y_i \quad (2)$$

$$\left(\sum x_i^2\right)a_0 + \left(\sum x_i^3\right)a_1 + \left(\sum x_i^4\right)a_2 + \left(\sum x_i^5\right)a_3 + \left(\sum x_i^6\right)a_4 = \sum x_i^2 y_i \quad (3)$$

$$\left(\sum x_i^3\right)a_0 + \left(\sum x_i^4\right)a_1 + \left(\sum x_i^5\right)a_2 + \left(\sum x_i^6\right)a_3 + \left(\sum x_i^7\right)a_4 = \sum x_i^3 y_i \quad (4)$$

$$\left(\sum x_i^4\right)a_0 + \left(\sum x_i^5\right)a_1 + \left(\sum x_i^6\right)a_2 + \left(\sum x_i^7\right)a_3 + \left(\sum x_i^m\right)a_4 = \sum x_i^4 y_i \quad (5)$$

Substitute the x and y values from the result of data into Equation 1 to 5 so that they can form a matrix equation as shown Equation 6.

$$\begin{bmatrix} \boldsymbol{n} & \sum x_i & \sum x_i^2 & \sum x_i^3 & \sum x_i^4 \\ \sum x_i & \sum x_i^2 & \sum x_i^3 & \sum x_i^4 & \sum x_i^5 \\ \sum x_i^2 & \sum x_i^3 & \sum x_i^4 & \sum x_i^5 & \sum x_i^6 \\ \sum x_i^3 & \sum x_i^4 & \sum x_i^5 & \sum x_i^6 & \sum x_i^7 \\ \sum x_i^4 & \sum x_i^5 & \sum x_i^6 & \sum x_i^7 & \sum x_i^8 \end{bmatrix} \times \begin{bmatrix} \boldsymbol{a_0} \\ \boldsymbol{a_1} \\ \boldsymbol{a_2} \\ \boldsymbol{a_3} \\ \boldsymbol{a_4} \end{bmatrix} = \begin{bmatrix} \sum y_i \\ \sum x_i y_i \\ \sum x_i^2 y_i \\ \sum x_i^3 y_i \\ \sum x_i^4 y_i \end{bmatrix} \quad (6)$$

from the matrix in Equation 6, to determine the value of a_0 can be determined from the determinant of the matrix Equation 7 divided by the determinant of the matrix Equation 8.

$$\boldsymbol{D_0} = \begin{bmatrix} \sum y_i & \sum x_i & \sum x_i^2 & \sum x_i^3 & \sum x_i^4 \\ \sum x_i y_i & \sum x_i^2 & \sum x_i^3 & \sum x_i^4 & \sum x_i^5 \\ \sum x_i^2 y_i & \sum x_i^3 & \sum x_i^4 & \sum x_i^5 & \sum x_i^6 \\ \sum x_i^3 y_i & \sum x_i^4 & \sum x_i^5 & \sum x_i^6 & \sum x_i^7 \\ \sum x_i^4 y_i & \sum x_i^5 & \sum x_i^6 & \sum x_i^7 & \sum x_i^8 \end{bmatrix} \quad (7)$$

$$\boldsymbol{D} = \begin{bmatrix} \boldsymbol{n} & \sum x_i & \sum x_i^2 & \sum x_i^3 & \sum x_i^4 \\ \sum x_i & \sum x_i^2 & \sum x_i^3 & \sum x_i^4 & \sum x_i^5 \\ \sum x_i^2 & \sum x_i^3 & \sum x_i^4 & \sum x_i^5 & \sum x_i^6 \\ \sum x_i^3 & \sum x_i^4 & \sum x_i^5 & \sum x_i^6 & \sum x_i^7 \\ \sum x_i^4 & \sum x_i^5 & \sum x_i^6 & \sum x_i^7 & \sum x_i^8 \end{bmatrix} \quad (8)$$

Therefore, it can be written that,

$$a_n = \frac{\boldsymbol{D_n}}{\boldsymbol{D}} \quad where\ n = 0, 1, 2, \quad (9)$$

from determining the variable values in Equation 9, we can determine the 4th order polynomial as shown in Equation 10 [10].

$$f(x) = y = a_0 + a_1 x + a_2 x^2 + a_3 x^3 + a_4 x^4 \quad (10)$$

C. Determination of Dip Value

The dip value is the standard value used by the Ministry of Religion, Republic of Indonesia to determine the time span from the appearance of dawn – *shadiq* to *shuruq* multiplied by the speed of the sun's journey [11]. For the speed

of the sun's journey, it is obtained from the division from dawn – *shadiq* to *shuruq* divided by 20^0 [12]. For more details, it can be seen in **Figure 6** [13].

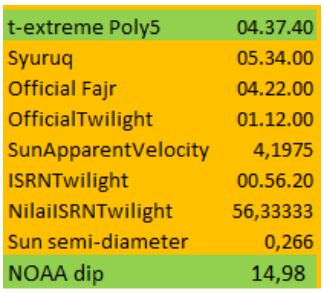


Figure 6. Dip Value

The dip calculation result of this research obtained 14.98^0, which is different from the dip value determined by the government amount 20^0. It is used by the government as the initial standard for entering dawn and in this study was 5.02^0 faster. NOOA Dip value is determined from Islamic Science Research Network (ISRN) - Twilight multiplied by sun semi – diameter, it can be seen as follows [13-15].

$$NOOA\ dip = 56{,}33^0 \times 0{,}266 = 14{,}98^0$$

Results and Discussion

In this study, the **Table 2** of data were taken from the number of photos, elapsed time, mean (average value) and standard deviation of the photos. Collection time starts 15 minutes prior to the dawn time set by the government. Retrieval of data at the flying height of the drone as far as 30 meters and taken continuously with a time range of 10 seconds. The supply of 3 drone batteries can last for 1 hour and produce as many as 350 photos. Data collection is located in the district of Citayam area, Municipality of Bogor, Indonesia. The following are the results of the data obtained on 02/10/2020. The processed data consists of sequentially captured photos at a regular interval of 2 minutes.

Table 2. Result of Data Processing

No	No of Item	Elapsed Time	Mean (deg)	Deviation Standard (deg)
1	327	4:25:40	41,640	14,445
2	339	4:27:40	41,548	14,524
3	351	4:29:40	36,631	12,957
4	363	4:31:40	41,001	14,401
5	375	4:33:40	41,871	14,537
6	387	4:35:40	36,778	13,128
7	399	4:37:40	41,854	14,701
8	411	4:39:40	42,137	14,802
9	423	4:41:40	37,340	13,158
10	435	4:47:40	42,826	15,569
11	447	4:49:40	37,518	13,187
12	459	4:51:40	38,243	13,446
13	471	4:53:40	38,297	13,375
14	483	4:55:40	39,273	13,466
15	495	4:57:40	46,037	16,90
16	507	4:59:40	42,405	13,98
17	519	5:01:40	38,243	13,47
18	531	5:03:40	38,297	13,38
19	327	5:05:40	39,273	13,47
20	339	5:07:40	46,037	16,90
21	351	5:09:40	84,492	55,52
22	363	5:11:40	109,683	80,59
23	375	5:13:40	117,337	89,01
24	387	5:15:40	123,739	96,50

No	No of Item	Elapsed Time	Mean (deg)	Deviation Standard (deg)
25	399	5:17:40	128,961	102,72
26	411	5:19:40	138,979	113,06
27	423	5:21:40	146,174	120,15
28	435	5:23:40	153,937	127,56
29	447	5:25:40	161,250	134,15
30	459	5:27:40	166,164	138,33

The result of image processing is analyzed and interpreted to determine the time of dawn prayer based on the detection of the moment of dawn. The data and findings from this analysis are used as a basis for determining the time of the morning prayer more accurately. The result of this study is compared with the traditionally determined time of the morning prayer to assess its accuracy.

After getting the recapitulation results of the mean and standard deviation values, then they are plotted to display a graph. The graph displays the time and standard deviation values, so that the brightness of the sky is getting brighter, marked by increasing disjointed blue dots as in **Figure 7**.

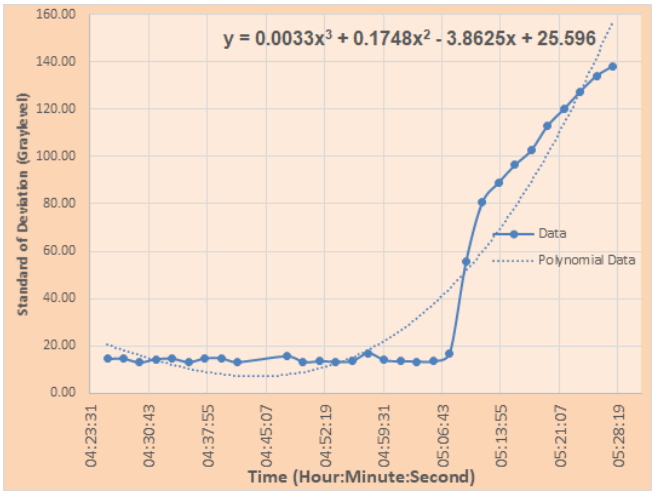


Figure 7. Graph of sky brightness data approximated by the 3rd order polynomial equation

The graph with a polynomial approach which in **Figure 7** is shown by the dotted line, resulting a model as in Equation 11 [10].

$$y = 0.0033x^3 + 0.1748x^2 - 3.8625x + 25.596 \quad (11)$$

Furthermore, this equation is calculated using the root formula of the equation, resulting in a rounded value that is used as the cut – off point as a sign of the appearance of dawn – *Shadiq*. The number used from the root of the equation is a positive number, in this study the result is $10.452 \langle 0.5311^0$ which is rounded up to 10. The number of ten indicates the time of the appearance of the first dawn – *Shadiq* that can be seen in **Table 2**, so that it is used to determine the beginning of morning prayer time.

10	435	4:47:40	42,826	15,569

This research is expected to provide benefits and contributions by determining the time of the morning prayer more precisely and accurately. This method employs image processing technology to assist Muslims in performing their morning prayers at the appropriate time as prescribed by Islamic teachings. Furthermore, the results of this study can provide better guidance for mosque managers and the community in determining the time of dawn prayer, particularly in conditions where weather circumstances prevent direct observation of the sun.

Meanwhile, the dawn time by the government from the website of the Ministry of Religion, Republic of Indonesia shows the dawn time on October 2nd, 2020, as shown in **Figure 8**.

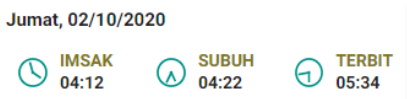


Figure 8. The time of dawn set by the government.

Conclusion

The use of camera in image processing offers an innovative approach for accurately determining the early time of prayer. By detecting early time moments through image processing, this potential research provides information on the dawn praying activity based on the right time and concordant to Islamic guidance with full awareness and sincerity. The data collected on 02-10-2020 from the website of the Ministry of Religion, Republic of Indonesia reveals that the morning prayer schedule by the government set at 04:22:00 WIB (West Indonesia Time), is 25 minutes ahead of the data obtained from the ISRN UHAMKA TEAM, which indicates a time 04:47:40 WIB. Dawn – *Shadiq* appears when the sun is at a dip of 14.98^0.

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