DETERMINING SUBUH PRAYER TIME USING GNU OCTAVE TO FIND POLYNOMIAL ROOTS

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Abstrak: Standar yang digunakan oleh pemerintah Indonesia untuk jadwal waktu sholat subuh adalah sudut ketinggian matahari 20°. Standar itu banyak dikoreksi karena dianggap belum terlambat. Penelitian awal pada waktu subuh banyak dilakukan dengan menggunakan alat fotometri sederhana yaitu SQM, pengolahan data keluaran SQM bervariasi, salah satunya dengan polinomial, dengan mereduksi fungsinya menjadi turunan kedua, dan akar turunan pertama disubstitusikan ke turunan kedua, sehingga solusi titik balik diwakili oleh 2y/∂2t <0. Aplikasi GNU Octaf membantu mencari akar turunan pertama lebih mudah dan sederhana dengan menulis perintah sehingga didapat akar turunan pertama. Dengan metode polinomial menggunakan GNU Octave dan menganalisis 19 data pengamatan menunjukkan bahwa sudut elevasi terendah adalah -21,53°, yang berarti 1,53 ° lebih cepat, atau 6 menit 7,2 detik dari jadwal resmi, dan sudut elevasi tertinggi adalah -11,38 ° atau 34 menit 28,8 detik lebih lambat. Rata-rata elevasi sudut Matahari adalah -16,59° ± 2,82° dengan selisih 3,41° atau 13 menit 38,4 detik dari jadwal resmi.
Kata Kunci: Waktu Sholat Subuh, Sky Quality Meter, Polinomial, GNU Oktaf.

Abstract: *The standard used for the dawn prayer time schedule by the Indonesian government is the sun elevation angle 20°. That standard has been corrected a lot because it has not been assumed too late. Early research at dawn is mostly done using simple photometry tools, namely SQM, the* *processing of SQM output data varies, one of which is by polynomials, by reducing its function to the second derivative, and the first derivative root is substituted into the second derivative, so the turning point solution is represented by $\partial^2 y/\partial^2 t$ <0. The GNU Octave application helps to find the root of the first derivative easier and simpler by writing commands so that the root of the first derivative is obtained. With the polynomial method using GNU Octave, analyzing 19 observational data shows that the lowest elevation angle is -21.53 °, which means 1.53 ° faster, or 6 minutes 7.2 seconds from the official schedule, and the highest elevation angle is -11.38 ° or 34 minutes 28.8 seconds slower. On an average the elevation of the Sun angle is -16.59 ° ± 2.82 ° with difference of 3.41 ° or 13 minutes 38.4 seconds from the official schedule.*

Keywords: *Subh prayer time, Sky Quality Meter, polynomials, GNU Octave*

Introduction

Prayer is the most crucial thing for Muslims. Prayer is done five times a day namely subuh, zuhur, ashar, maghrib and isya. For the dawn, lately various parties cast criticisms of the standards used generally in Indonesia and in various other parts of the world. The critics say that the standard used for official schedules, such as in Indonesia uses the sun's elevation angle of -20 °, which means when the sun's elevation angle is at 20 ° under the horizon of the dawn light has not yet appeared in the Eastern horizon. The critique on eary determination of Subh prayer time as being too early has been around since 2010 in a article published in Qiblati magazine titled "*Salah Kaprah Waktu Subuh"* [1], by a prominent newspaper, Republika, reviewed the results of research conducted by The Islamic Science Research Network which states that the dawn time used generally today is too fast [2]. There have been several studies that state the same thing, as conducted by Herdiwijaya [3], [4], Arumaningtyas [5], Bahali [6], Shariff [7]–[9]. In the research carried out, the researchers used a simple photometric instrument called the Sky Quality Meter (SQM) [10]–[25] as conducted by Herdiwijaya [3], [4], Arumaningtyas [5], Shariff [7]–[9], [17], [26], Saksono [27], and Raihana [28]. Some also use image processing from DSLR cameras such as Bahali [6].

SQM is a photometric tool that functions to quantify the value of sky darkness in units of magnitude per arcsecond square (mpsas) [29], the result of SQM is form of sky darkness data. According to the SQM settings the time interval is taken for the level of darkness, so the data generated in addition to the darkness data is also the timestamp data. From the data of the darkness value and the timestamp, the researchers analyzed when the appearance of the dawn light became a sign of the early of dawn. SQM data processing methods in the form of graphs that change the profile of the darkness of the sky actually vary to determine the appearance of the dawn light, there are those that divide the changes in the level of darkness in several phases like Shariff [7]–[9], [17] and this looks still very manual in determining the presence of dawn light from SQM data. However, there are also those who have done the statistical analysis approach using polynomial functions, as did Saksono [27] to find the turning point of the graph which is assumed to be the point of presence of dawn light because it is a point of change from dark to light. The step of using the polynomial function to determine the turning point is to reduce the polynomial function to 2 stages, namely the first derivative and the second derivative, the root of the first derivative function is used in the second derivative function and which produces negative values is the solution of the turning point. In the process of finding the roots of the first derivative of the polynomial function if done with manual calculations is very time consuming, the writers use the GNU Octave application which is a numerical processing application to find the roots of the first derivative of the polynomial function. Using GNU Octave is relatively easy and open sourcebased, so the process of analyzing SQM data is simpler.

Materials And Methods

1. Equipment and Application

In the process of observing the level of darkness of the sky used a photometric tool called Sky Quality Meter (SQM) [29] which produces data in .cvs format, for processing SQM output data used LibreOffice Calc production of LibreOffice based on open source is an application used to create and manipulate numerical data, words and atematis formulas [30] in this study are used to process the SQM results data and then plot them simply to obtain polynomial functions. GNU Octave is an application for nurmeric processing whose commands are carried out through the commandline and are mostly compatible with the matlab application [31]–[34], GNU Octave is used to look for root derivatives of polynomial functions. Finally, the writers use the GNU Plot, which is a portable command-line driven graphing utility for various computer operating system platforms [35]–[37], the GNU Plot is used to plot data and functions. The data we use for analysis must have a good darkness profile with no light disturbances around the moment of the curve turning point or a disturbing light source that dominates so that the profile fluctuates.

2. Technique of Analysis

In summary, the steps in conducting research at dawn are: (1) observing with SQM, (2) data conversion from .csv format to LibreOffice Calc or forat. .xls, to be plotted and obtained the polynomial function simply, (3) still on the .xls worksheet, write down the polynomial function, first derivative and second derivative (4) find the root of the first derivative function using the GNU Octave (5) enter the derived roots into the second derivative, and (6) plotting data with the GNU Plot. All the above processes are illustrated in Figure 1.

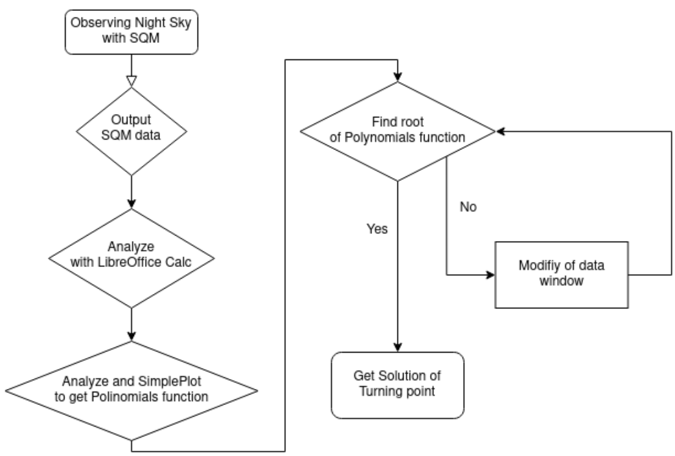

Figure 1: Researchs flowchart

Analysis with polynomial functions, such as degree 3 polynomial which is mathematically expressed as $y = p_3d_i^3 + p_2d_i^2 + p_1d_i + p_0$, where p_i (p_3, p_2, p_1, *and* p_0) are constants that are real numbers or complex numbers, with $p_i \neq 0$ and i is a non-negative integer [38], while the first derivative is denoted $\partial y/\partial t = 3p_3d_i^2 + 2p_2d_i + p_1$, and the second derivative $\partial^2 y/\partial_2 t = 6p_3d_i + 2p_2$. Then the root of $\partial y/\partial t$ is substituted to $\partial^2 y/\partial 2t$ and a turning point solution is obtained if it fills $\partial^2 y/ 2_t < 0$. To get the root of $\partial y/\partial t$, so $\partial y/\partial t$ is entered into the GNU Octave application. For example, from observational data made at Tanjung Kelayang Beach, Belitung (-2.5585868 N, 107.6694 E) as in Figure 2.

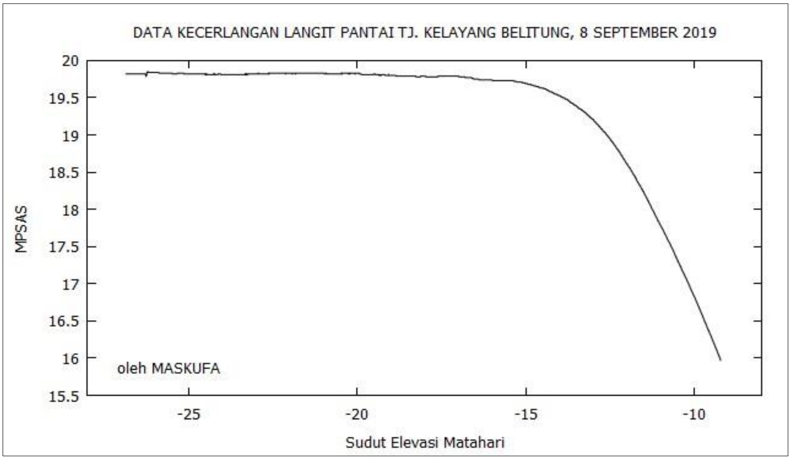

Figure 2: Night Sky Brightness (NSB) at Tanjung Kelayang Beach Belitung, September 8 2019

∂^{3} + *7.00E-06*x^2 + *-1.10E-03x* + *1.98E01,* so $\partial y/\partial t = -3.00E - 08x2$ + 1.40E – For y = *-1.00E-08x* 05 – 1.10E – 03, and $\partial_2 y/\partial_2 t = -6.00E - 08x$ + 1.40E – 05. $\partial y/\partial t$ is written into GNU Octave application become A = [–3.00E – 08, 1.40E – 05, –1.10E – 03], and to find the root by writing roots command *(A)*, so that the roots are obtained to be substituted into $\partial_2 y/\partial_2 t$.

```
>> A=[-3.00E-08, 1.40E-05, -1.10E-03]
A =

  -0.000000030000   0.000014000000  -0.001100000000

>> roots(A)
ans =

   366.67
   100.00

>> |
```

Figure 3: Command for root finding

3. Location

We did the observations in 2018 and 2019 in some areas such as in Table 1, observations were made since 4:00 a.m. until the sun rises. Four locations on Java Island, two locations in West Papua, two locations in Kalimantan, two locations in Belitung Island, one location in East Nusa Tenggara island and one location in North Sulawesi.

Table 1: Observation Location

Name of Location	Latitude	Longitude
Pantai Krakal, Yogyakarta	-8,148838 S	110,59573 E
Bukit Panguk, Kediwung Yogyakarta	-7,959344 S	110,44116 E
Manembonembo Atas, Bitung Sulut	1,441422 N	125,11502 E
Ged. DPRD, Manokwari, Papua Barat	-0.892092 S	134.040975 E
STKIP, Manokwari, Papua Barat	-0.924186 S	134.042881 E
Hotel Yayang, Balikpapan	-1.259266 S	116.908644 E
Pantai Angkasa, Balikpapan	-1.263404 S	116.914335 E
Bukit Sylvia, Labuanbajo	-8.461438 S	119.874781 E
Belitung, Pantai Tanjung Tinggi	-2.551006 S	107.712736 E
Belitung,Pantai Tanjung Kelayang	-2.558618 S	107.669469 E
Parung, Bogor	-6,4267648 S	106,70778 E
Gedangan, Sidoarjo	-7.399985 S	112.705573 E

Result

From all observational data processed with various of polynomial degrees, from degrees 3 to degrees 6 as shown in Table 2. The lowest elevation angle is obtained -21.53 ° which means 1.53 ° faster, or 6 minutes 7.2 seconds faster than the official schedule which is used by the Indonesian government. While the highest elevation angle is -11.38 ° which means the difference with the official schedule is 8.62 ° or 34 minutes 28.8 seconds slower. On average the data obtained from 19 data is -16.59 ° with a difference of 3.41 ° or 13 minutes 38.4 seconds from the official schedule.

Table 2: Result of observation

Name of Location, Date, and SQM Serial Number			**Location**		**Solution**	**Degree of Polynomials**
			Latitude	**Longitude**		
Pantai Krakal, Yogyakarta	21/07/18	AL0316VH	-8,148838 S	110,59573 E	–19,49	Pol.5
Bukit Panguk, Kediwung Yogyakarta	22/07/18	AL0316VH	-7,959344 S	110,44116 E	–18,58	Pol.5
Manembonembo Atas, Bitung Sulut	13/09/18	AL0316VH	1,441422 N	125,11502 E	–15,07	Pol.5
Ged. DPRD, Manokwari, Papua Barat	09/12/18	AL0316VH	-0.892092 S	134.040975 E	–18,65	Pol.3
STKIP, Manokwari, Papua Barat	10/12/18	AL0316VH	-0.924186 S	134.042881 E	–15,90	Pol.3
Hotel Yayang, Balikpapan	14/12/18	AL0316VH	-1.259266 S	116.908644 E	–12,81	pol.4
Pantai Angkasa, Balikpapan	15/12/18	AL0316VH	-1.263404 S	116.914335 E	–12,81	pol.4
Bukit Sylvia, Labuanbajo	31/08/19	AM00H7MU	-8.461438 S	119.874781 E	–21,53	Pol.5
Bukit Sylvia, Labuanbajo		AL0316VH	-8.461438 S	119.874781 E	–16,42	Pol.4
Bukit Sylvia, Labuanbajo	01/09/19	AM00H7MU	-8.461438 S	119.874781 E	–19,64	Pol.6
Bukit Sylvia, Labuanbajo		AL0316VH	-8.461438 S	119.874781 E	–18,18	Pol.5
Belitung, Pantai Tanjung Tinggi	07/09/19	AL0316VH	-2.551006 S	107.712736 E	–17,45	Pol.4
Belitung,Pantai Tanjung Kelayang	08/09/19	AL0316VH	-2.558618 S	107.669469 E	–17,44	Pol.3
Belitung,Pantai	08/09/19	AM00H7M	-2.558618 S	107.669469 E	–15,45	Pol.3

Tanjung Kelayang		U				
Parung, Bogor	28/09/19	AM00H7MU	-6,4267648 S	106,70778 E	−14,44	Pol.4
Parung, Bogor	29/09/19	AM00H7MU	-6,4267648 S	106,70778 E	−14,24	Pol.3
Parung, Bogor	06/10/19	AM00H7MU	-6,4267648 S	106,70778 E	−11,38	Pol.4
Gedangan, Sidoarjo	28/09/19	AL0316VH	-7.399985 S	112.705573 E	−20,85	Pol.3
Gedangan, Sidoarjo	01/10/19	AL0316VH	-7.399985 S	112.705573 E	−17,78	Pol.5
Mean					−16,74	
Standart Deviation					2,82	

Conclusion

The use of the GNU Octave application greatly facilitates the process of analyzing data to find the roots of polynomial functions, so that the analysis process becomes simpler. The observations show that there is a difference between the standard of sun elevation angle used for the official schedule by the Indonesian government and the observations using SQM, on average the difference is 3.41 ° or 13 minutes 38.4 seconds with a standard deviation of 2.82. Hopefully the government will immediately evaluate the standard used in arranging the prayer time schedule.

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