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Hilal Observation using LRGB Filters

Muhammad Dimas Firdaus [a,1,*], Hariyadi Putraga [a,2], Marataon Ritonga [a,3], Arwin Juli Rakhmadi [a,1]
[a] Observatorium Ilmu Falak Universitas Muhmmadiyah Sumatera Utara, Medan, 20226, Indonesia
[1] mdimasfirdaus@umsu.ac.id; [2] hariyadiputraga@umsu.ac.id; [3] marataonrionga@umsu.ac.id
Corresponding Author: No. HP (085315328046)

Abstract: *The technology used in hilal observation continues to develop. Most recently, using filters has become one of the options in hilal observation. Several filters can be used, ranging from low wavelengths like ultraviolet to high wavelengths like infrared. In some ideas, there needs to be a limit to the use of filters, the human eye's ability as a benchmark for the filter used. The human eye is sensitive to light with visual wavelengths, and one type of filter in this range is the LRGB filter. In this study, hilal observations were made on four filters and compared to find out which filter is better at increasing the contrast of hilal against the background. Using Michelson and Weber contrast as the definition of contrast to determine the comparison of the brightness value of the object with the background. From the observations made, it is found that the R filter will produce higher contrast values at low altitudes, followed by the L, G, and B filters. However, at higher altitudes, the contrast values of the L and R filters are similar, while the G and B filters remain low.*
Keywords: *Hilal Observation, Filter, LRGB.*

Abstrak: *Teknologi yang digunakan pada pengamatan hilal terus berkembang, terkini penggunaan filter menjadi salah satu pilihan dalam pengamatan hilal. Ada beberapa jenis filter yang bisa digunakan, mulai dari panjang gelombang rendah seberti filter ultraviolet, hingga panjang gelombang tinggi seperti inframerah. Pada beberapa ide perlu ada batasan penggunaan filter, yaitu kemampuan mata manusia sebagai benchmark filter yang digunakan. Mata manusia memiliki sensitivitas pada cahaya dengan panjang gelombang visual dan salah satu jenis filter yang berada pada rentang ini adalah filter LRGB. Pada penelitian ini dilakukan pengamatan hilal pada 4 filter dan dibandingkan untuk mengetahui filter mana yang lebih baik dalam meningkatkan kontras hilal terhadap latar belakang. Menggunakan kontras Michelson dan Weber sebagai definisi kontras untuk mengetahui perbandingan nilai kecerahan dari objek dengan latar belakang. Dari pengamatan yang dilakukan didapati bahwa filter R akan menghasilkan nilai kontras yang lebih tinggi dari pada ketinggian rendah, diikuti oleh filter L, G dan B. Namun pada ketinggian yang lebih tinggi nilai kontras fiLter L dan R serupa, sementara filter G dan B tetap rendah.*
Kata Kunci: *Pengamatan Hilal, Filter, LRGB.*

A. Introduction

One of the main activities in learning *falak* is hilal observation. Various modes are used in the hilal observation process, ranging from naked eye observation without instruments, with instruments to localize the position of the hilal, with optical aids, to cameras with various features.[1] The use of instruments as aids is still limited, and not all the latest technology can be applied directly to hilal observation. One of the limitations of the use of aids is the ability of the human eye.

In the study of falak, the human eye's ability variables can be improved with instruments, such as field of view, light-gathering power, and contrast. This is accommodated by some

[1]T. Hidayat et al., "Developing Information System on Lunar Crescent Observations," *ITB Journal of Sciences* 42, no. 1 (2010): 67–80, https://doi.org/10.5614/itbj.sci.2010.42.1.6.

contemporary fiqh opinions regarding using instruments in hilal observation. Such as the opinion of Prof. Ahmad Rofiq, Professor of the Faculty of Sharia UIN Walisongo Semarang, who explained that the use of instruments is only as a tool, but the user behind the tool is still a human who determines whether the moon is visible or not. There are also other opinions such as that of Prof. Huzaemah T. Yanggo (Chairman of MUI for Fatwa) who explained that the use of instruments is a good thing in utilizing scientific advances to help matters of worship. With a note during the process of taking pictures until issuing results can be scientifically accounted for.[2]

However, some variables, such as wavelength, cannot be increased with instruments. So, the instruments used are limited to visual wavelengths (visible light) by the vision capabilities of the human eye.[3] The wavelength of visible light spans from 350nm to 750nm and is divided into several colours. The human eye will capture light at all wavelengths, resulting in less contrast being perceived. To increase contrast, you can limit what wavelengths you need to observe. In astronomical observations, several types of filters can be used to restrict the wavelengths detected by the camera. Standard filters used in astronomical observations are narrow and wide-band filters. Hydrogen-alpha, Sulfur, and Oxygen are examples of narrow-band filters used in astronomical observations. At the same time, the wide-band filters commonly used in astronomical observations are UBVRI and LRGB.

Perceptual Manifestation	Wavelength	Frequency	Energy
Violet	380–450 nm	668–789 THz	2.75–3.26 eV
Blue	450–495 nm	606–668 THz	2.50–2.75 eV
Green	495–570 nm	526–606 THz	2.17–2.50 eV
Yellow	570–590 nm	508–526 THz	2.10–2.17 eV
Orange	590–620 nm	484–508 THz	2.00–2.10 eV
Red	620–750 nm	400–484 THz	1.65–2.00 eV

Figure 1 Human Eye Visual Wavelengths

Wide-band filters are required to accommodate observations with a wide range of wavelengths, UBVRI or LRGB. UBVRI is commonly used in astrophotometric observations, with a wide range of wavelengths from Ultraviolet (320 nm) to Infrared (900nm). In comparison, LRGB is commonly used in astrophotographic observations with visual wavelength restrictions, from Blue (450nm) to Red (750nm).

[2] Riza Afrian Mustaqim, "Pandangan Ulama Terhadap Image Processing Pada Astrofotografi Di BMKG Untuk Rukyatul Hilal," *Al-Marshad: Jurnal Astronomi Islam dan Ilmu-Ilmu Berkaitan* 4, no. 1 (June 30, 2018): 78–115, https://doi.org/10.30596/jam.v4i1.1937.

[3] Abu Sabda, *Ilmu Falak: Rumusan Syar'i dan Astronomi*, 1st ed., 2 (Bandung: Persis Pers, 2019).

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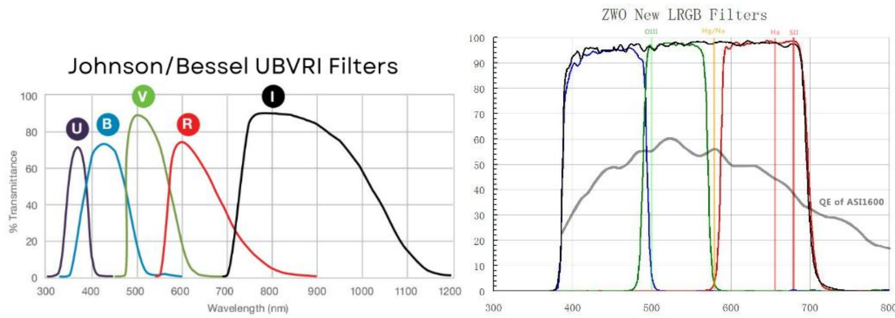

Figure 2 Comparison of UBVRI filters and LRGB filters

As explained earlier, hilal observations are limited to the ability of the human eye to receive photons in visual wavelengths. This research focuses on observations with the help of LRGB filter instruments. This research intends to find out which filter is better at enhancing the contrast of the hilal, unlike previous studies that used colour cameras for further processing based on RGB filters.[4] or other colour filters[5]. This research used filters that were directly physically embedded in the monochrome camera.

Some previous studies suggest that using infrared filters can increase the contrast of the new Moon.[6] However, it should be noted that these studies focused on daytime observations when the background sky is blue. Indeed, conditions are different when observations are made after sunset.[7] Observations during the day when the sky is typically blue are usually to obtain very thin hilal conditions, with very small elongations.[8] Additional tools, such as baffles, are needed to assist the observation.[9] In this study, the data used is the data of young hilal that can be observed after sunset. OIF UMSU, a centre for the study of falak,[10] Is trying to continue innovating in the development of falak.

[4]Arsyita Baiti Musfiroh, “Citra RGB (Red, Green & Blue) dalam Image Processing Hilal untuk Penentuan Awal Bulan Kamariah” (Semarang, Universitas Islam Negeri Walisongo, 2023).

[5]Hariyadi Putraga et al., “Pengamatan Hilal Siang Menggunakan Metode Olahan Filter Warna pada Software Iris,” *SPEKTRA: Jurnal Kajian Pendidikan Sains* 7, no. 1 (April 28, 2021): 49, https://doi.org/10.32699/spektra.v7i1.187.

[6]P. Mahasena et al., “CCD Observation of Daylight Crescent Moon at Bosscha Observatory,” *Journal of Physics: Conference Series* 1127 (January 2019): 012049, https://doi.org/10.1088/1742-6596/1127/1/012049.

[7]Muhammad Dimas Firdaus et al., “Study of Hilal’s Contrast Using Infrared Filter in Daylight Hilal Observation,” *International Seminar of Islamic Studies* 4, no. 1 (2023): 614–621.

[8]Muhammad Yusuf, Mochamad Irfan, and Yatny Yulianty, “Pencitraan Bulan Pada Saat Konjungsi,” *Journal of Multidisciplinary Academic* 3, no. 2 (2019): 32–36.

[9]Dhani Herdiwijaya et al., “Developing Telescope Baffle for Increasing Contrast of The Very Young Lunar Crescent Visibility,” *Proceedings of the Third International Conference on Mathematics and Natural Sciences*, 2010, 1214–1220.

[10]Muhammad Qorib et al., “Peran dan Kontribusi OIF UMSU dalam Pengenalan Ilmu Falak di Sumatera Utara,” *Jurnal Pendidikan Islam* 10, no. 2 (November 30, 2019): 133–41, https://doi.org/10.22236/jpi.v10i2.3735.

B. Method

This research uses direct observation and data collection in person as the primary method. Data were taken at the Barus Branch of Observatorium Ilmu Falak of Universitas Muhammadiyah Sumatera Utara (2.006N, 98.721E) when the hilal could be observed after sunset. Data were collected at the beginning of Dhu al-Qa'dah 1444H, which coincides with May 21, 2023, and the hilal of the beginning of Dhu al-Hijjah 144H, which coincides with June 19, 2023.

The instruments used in this research are a telescope set (tube and mount), a monochrome dedicated astronomical camera, an LRGB filter set (filter and filter wheel), and a laptop. The following is a complete list of instruments used in this study.

Table 1 Observation Instruments

No	Instruments	Detail
1	Telescope	William Optics Zenithstar 71 ED
2	Camera	ZWO ASI 178 MM
3	Mounting	Sky-Wacther HEQ 5 Pro
4	Filter	ZWO 36mm LRGB Filter
5	Filter Wheel	ZWO EFW 7x36mm
6	Laptop	Acer Aspire E 14

Figure 3 Observing Hilal

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After the observation data is obtained, the intensity value of each image will be measured using AstroImageJ.[11] software, and then the contrast value will be measured. Measurement of contrast values using Microsoft Excel software with two mathematical definitions of contrast: Michelson's Contrast and Weber's Contrast.[12]

Weber's contrast is defined as follows:

$\frac{I-I_b}{I_b}$ (Equation 1)

Where:

I = object brightness

I_b= sky background brightness

Michelson's contrast is defined as follows:

$\frac{(I_{max}-I_{min})}{I_{max}+I_{min}}$ (Equation 2)

Where:

I_{max} = maximum brightness

I_{min} = minimum brightness

These two definitions are based on previous research on the contrast of the new Moon to the background sky. One of them is the research conducted by Sulthan to get the best time for hilal observation.[13]. There is a similarity between the mathematical and practical definition of contrast in hilal observation, which compares the intensity value of the object to the intensity value of the background sky. The further the difference, the higher the contrast value.

[11]Karen A. Collins et al., "AstroImageJ: Image Processing and Photometric Extraction for Ultra-Precise Astronomical Light Curves," *The Astronomical Journal* 153, no. 2 (February 1, 2017): 77, https://doi.org/10.3847/1538-3881/153/2/77.

[12] Adi Damanhuri, "Desain Sistem Pengamatan Sabit Bulan di Siang Hari," *Seminar Nasional Sains dan Teknologi Fakultas Teknik Universitas Muhammadiyah Jakarta*, 2015, 1–19.

[13] A H Sultan, "'Best Time' for The First Visibility of The Lunar Crescent," *The Observatory* 126, no. 1191 (2006): 115–18.

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C. Result and Discussion

1. Result

The data obtained from observations at two different times are images in four different filters. Each photo was taken in .avi video format and converted into .fit image format to be analyzed for intensity values using PIPP software. The details of each piece of data obtained are as follows:

Table 2 Data from the first observation (May 21, 2023)

No	Filter	Time	Frame	Exposure	Gain	Altitude	Elongation	Illuminated
1	L	19:06:31	89	56.1810ms	230	10°50'32"	21°15'13"	3.4%
2	R	19:06:48	90	56.1810ms	230	10°46'54"	21°15'20"	3.4%
3	G	19:07:02	91	56.1810ms	230	10°43'55"	21°15'26"	3.4%
4	B	19:07:21	91	56.1810ms	230	10°39'52"	21°15'33"	3.4%

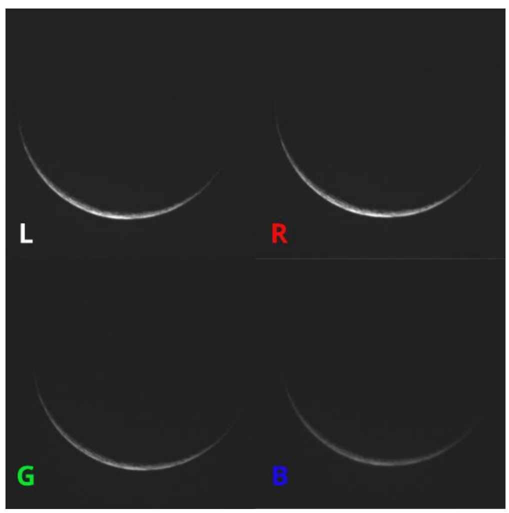

Figure 4 The Image From Each Filter

Table 3 Data from the second observation (June 19, 2023)

No	Filter	Time	Frame	Exposure	Gain	Altitude	Elongation	Illuminated
1	L	19:05:16	14	356.5ms	59	6°36'44"	14°44'18"	1.7%
2	R	19:05:38	15	356.5ms	59	6°32'06"	14°44'27"	1.7%
3	G	19:05:49	15	356.5ms	59	6°29'35"	14°44'31"	1.7%
4	B	19:06:02	15	356.5ms	59	6°26'51"	14°44'37"	1.7%

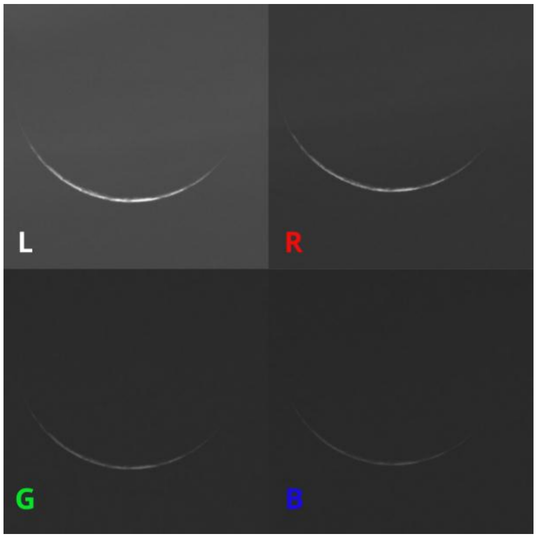

Figure 5 The image from each filter

Significant differences exist between the two observations, especially in altitude and elongation. However, both conditions are the same: the sky is still transitioning from day to night, so the background sky is no longer blue but not yet completely dark. This situation is different from daytime hilal observations.

To focus on the changes in contrast affected by the different filters used, the camera settings in each filter were equalized. The instrument, also equipped with a filter wheel, makes it easy to switch from one filter to another, which is very helpful so that the image capture time does not differ significantly. This treatment is necessary so that when differences in contrast values are found, the difference in filters used is affected.

After each image is converted into still image format with PIPP, each image is analyzed for intensity values using AstroImageJ. From each image, the maximum value representing the hilal object and the minimum value representing the background sky are taken. Because the number of frames obtained is different, to simplify the calculation of the contrast value, only a sample of 10 frames per image is taken and then averaged to get the final value of the image contrast.

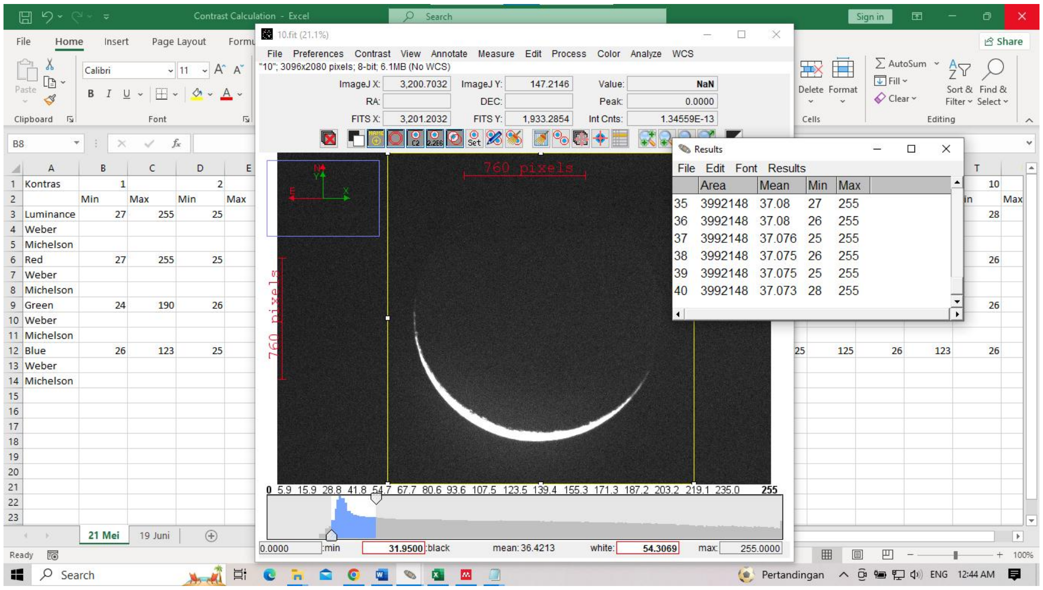

Figure 6 Analyzing the intensity

Table 4 Recapitulation of image intensity values on May 21, 2023

No	Filter	Min	Max
1	L	26.1	255
2	R	26.2	255
3	G	25.5	190.3
4	B	25.4	124.5

Table 5 Recapitulation of image intensity values on June 19, 2023

No	Filter	Min	Max
1	L	67.2	255
2	R	48	210.1
3	G	40	121.8
4	B	38.1	85.4

By using Equation 1 to find the Weber contrast value and Equation 2 to find the Michelson contrast value, the respective contrast values of the eight images can be obtained as follows:

Table 6 Contrast

No	Date	Filter	Michelson Contrast	Weber Contrast
1	21st May 2023	L	0.814301	8.770115
		R	0.813656	8.732824

		G	0.763670	6.462745
		B	0.661107	3.901575
2	19th June 2023	L	0.582868	2.794643
		R	0.628051	3.377083
		G	0.505562	2.045
		B	0.382996	1.24147

2. Discussion and Analysis

The observation results on May 21, 2023, show that the contrast produced by the L filter and R filter tends to be similar, with a difference of 0.000645 in Michelson's contrast and a difference of 0.037291 in Weber's contrast. Meanwhile, the contrasts produced by the G and B filters are pretty far apart. This is natural considering that Moonlight entering the Earth's atmosphere is generally around 400nm at the full Moon[14] and continues to weaken to around 700nm at the new Moon. At the same time, the background sky is still affected by Sunlight. With the height far enough away from the horizon, the influence of Sunlight is not so significant that the contrast values resulting from the L and R filters are not much different.

On June 19, 2023, observations at a lower altitude produced different values. It can be seen that the contrast of the R filter is very high compared to the other filters. At a reasonably low altitude, the influence of Sunlight is still quite strong, so using the R filter can cut the light and increase the contrast of the hilal. However, the G and B filters produce very low contrast as on previous dates.

This contrast value is quite influenced by the thickness of the hilal, which is a function of elongation, and the brightness of the background sky, which is a function of the height of the hilal[15]. The further away the Moon is from the Sun, the less disturbance there is in the background sky, and the greater the Moon-Sun elongation, the thicker the Moon will be. Combining the two can increase the contrast value of the new Moon.

Although it has been attempted that the conditions for taking images on each filter are the same because different filters require a different focus, and the focus used in all observations is the focus of filter L, so for other filters, there may be off-focus, especially in filters G and B. Despite the off focus, the Moon's disk is still clearly visible, so we think the results are relevant.

This research is expected to provide new insights into hilal observation. Currently, hilal observation activities are dominated by the naked eye modus, making it difficult to verify the

[14] J-C. Breitler et al., "Full Moonlight-Induced Circadian Clock Entrainment in Coffea Arabica," *BMC Plant Biology* 20, no. 1 (December 2020): 24, https://doi.org/10.1186/s12870-020-2238-4.

[15] Eka Puspita Arumaningtyas and Moedji Raharto, "A Study of The Impact of Sky Brightness on Hilal Visibility," n.d.

truth.[16] When observations use imaging more, it will make it easier for other researchers to study them. The addition of instruments such as LRGB filters can focus the study.

Observations made by utilizing advances in science and technology open up wider opportunities. Observations are not only made by Muslims; if they are equipped with adequate instruments such as cameras, telescopes, and filters, observations made by non-Muslims can also be accepted.[17] The location of observations can be increased by looking for good location conditions, not only in Muslim-majority areas.

D. Conclusion

Observations of the hilal equipped with filters with longer wavelengths can produce higher contrasts than those with shorter wavelengths. However, this applies at lower Moon-Sun distances when the background sky is still sufficiently affected by Sunlight. However, when the Moon's altitude is higher, the contrast value produced by the R filter does not differ much from that of the L filter, which receives photons at all visual wavelengths. This study is the beginning of the development of astronomical filters in hilal observation. More hilal observations with various filters are still needed to determine better effectiveness.

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