STUDY OF HILAL'S CONTRAST USING INFRARED FILTER IN DAYLIGHT HILAL OBSERVATION

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Abstract: *Hilal observation has already undergone a very significant development of techniques. From daytime observations, up to the uses of various instruments that can support the success of observations. One of the routine activities carried out by the Falak Science Observatory of Muhammadiyah University of North Sumatra is daytime hilal observation. The hilal observation conducted by OIF UMSU uses an infrared filter instrument that can transmit light at infrared wavelengths and filter light at other wavelengths. This research tries to compare the contrast of daylight hilal images taken using filters and not using filters.The results obtained from the experiments carried out resulted in a contrast value using an infrared filter is 129% using Weber contrast analysis, and 4% using Michelson contrast analysis.*

Keywords: *Daylight Hilal, Infrared Filter, Contrast, OIF*

Introduction

Islam as a universal and progressive religion has a great intersection with the development of science and technology. One of the branches of science that intersects directly between Islam and the advancement of science and technology is falak science, in other words Islamic astronomy (Rakhmadi,2015). In practical terms, falak science directly combines Islamic law with science and technology. The subject matter of falak science is the study of the fiqh on worship which needs science to facilitate the process of worship. Hence, many falak science subjects are based on science and technology, one of which is hilal observation.

The hilal observation is one of the routine activities carried out by falak or astronomy practitioners in Indonesia. Basically, this observation is done to determine the beginning of the lunar month at the end of each month. There are many definitions of hilal used in Indonesia, with various backgrounds (Raisal, 2018). The common definition of hilal is first crescent Moon phase that can be observed after sunset at the end of the month, this definition is widely mentioned by classical scholars such as Abu Ja'far, al-Zamakhshari, al-Razi, al-Jauhari, al-Maragi and Wahbah al-Zuhaili (Hamdani, 2017). However, in the modern era, hilal observation is not only done at the end of the month to mark the beginning of the next month. Many observers try to get the hilal during the day. The hilal in this context is a thin crescent of the Moon either before conjunction or after conjunction. So that in this study the author limits the terminology of hilal as a young/old crescent Moon phase.

The daylight hilal observation is not separated from the various controversies behind it. Some opinions say that hilal observed during the day cannot be called hilal to determine the beginning of the month because it does not fulfill the definition of hilal in fiqh. On the other hand, some opinions try to make a breakthrough that this technique can assist in the hilal observation process under the name Rukyat Qabla Gurub. (RQG) (Rofiuddin, 2019). Apart from these problems, daylight hilal observation can contribute to the scientific and observational repertoire of falak science.

As we mentioned earlier, many observers have tried to get the noon hilal. On the ICOP website, the record for the thinnest hilal is owned by Thierry Legault from France who succeeded in capturing the hilal right when the geocentric conjunction occurred with an elongation of only 4,554 degrees. Not only abroad, in Indonesia there are also many observations made to get the daylight hilal such as at Bosscha Observatory (Mahasena, 2019), ISRN UHAMKA (Damanhuri, 2018), and also at the Falak Science Observatory of Universutas Muhammadiyah Sumatera Utara (Firdaus, 2022).

The Observatory of Falak Science of Universitas Muhammadiyah Sumatera Utara is an institution that focuses on the development of falak science and astronomy in North Sumatra. OIF UMSU is committed to contributing to the development and study of falak science, both in the form of research and service (Qorib, 2019). With the spirit of progressive Islam, OIF UMSU also conducts hilal observations with the most recent techniques (Hidayat, 2010). There have been several studies related to daylight hilal conducted by OIF UMSU, Daytlight Hilal Observation Using the Color Filter Process Method in IRIS Software (Putraga, 2021) and Daylight Hilal Observation at OIF UMSU Barus Branch (Firdaus, 2022).

Daylight hilal observations have a slightly different challenge from evening observations, which is very low contrast. The amount of contrast is determined by the difference between the brightness of one object and another. During the day the sky looks very bright, while the hilal also has a low brightness, making it very difficult to observe. To increase the contrast of hilal during the day, some additional instruments are needed, such as infrared filters and baffles (Herdiwijaya, 2010).

An important point that distinguishes this study from existing studies is the comparison of contrast between images using infrared filters and without infrared filters. Another difference is the filter wavelength used, in Damanhuri's study a wavelength range filter of 700 nm was used and in Mahasena's study a wavelength range filter of 740 nm was used. While in this study the author used a filter with a wavelength of 685 nm.

Literature Review

Contrast in visuals is a property of an image that makes an object distinguishable from other objects or the background. In the visual view, contrast can be determined by two things, which are color and brightness (Felix, 2010). Apart from the observed object, contrast can also be adjusted during image processing, using several available software.

Color contrast is determined by the interaction of a color with another color. To determine the value of color contrast, a color wheel can be used. Colors that are in opposite positions have higher contrast levels, while colors in adjacent positions have lower contrast.

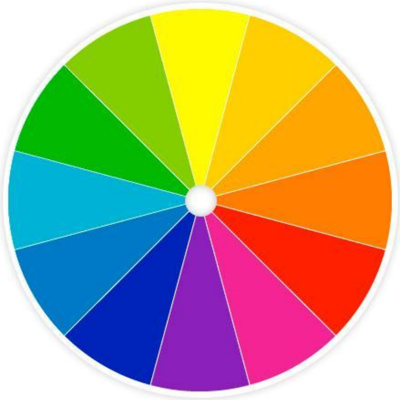

Figure 1: Color Wheel

Brightness contrast is determined by the brightness level between an object and another object, between a lighter object and a darker object. The higher the difference in brightness between two objects, the higher the contrast value. Unlike color contrast that only applies to color images, brightness contrast applies to all types of images.

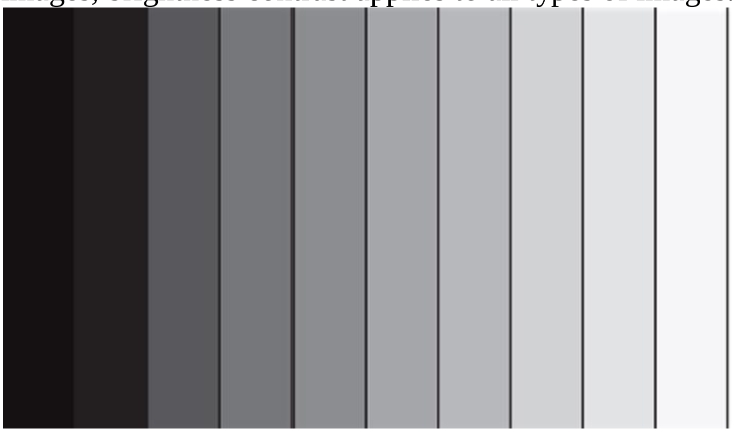

Figure 2: Brightness Difference in Contrast

To obtain a high-contrast image of the hilal, observations are recommended using a monochrome camera. This is so that more light can enter and the contrast assessed is only the brightness contrast. Since the camera used is a monochrome camera, the contrast discussed in this study is brightness contrast. There are several mathematical definitions of contrast in an image, which are Weber contrast, Michelson contrast, and Root Mean Square Contrast.

Weber contrast is defined as follows:

$$\frac{I-I_b}{I_b}$$

Where:

I = object brightness

I_b = background brightness

Michelson contrast is defined as follows:

$$\frac{I_{max}-I_{min}}{I_{max}+I_{min}}$$

Where:

I_{max} = maximum brightness

I_{min} = minimum brightness

Root Mean Square Contrast is defined as follows:

$$\left[\frac{1}{N-1}\Sigma\left(I_i - \underline{I}\right)^2\right]^{\frac{1}{2}}$$

Where:

N= pixel number in image

I_i= normalize value of 1 brightness intensity

$\underline{I}$ = total brightness intensity in image

The application of contrast value in hilal observation has been carried out by several researchers to formulate hilal visibility criteria. The author summarizes the contrast formula used by Ilyas (1988), Schaefer (1993) and Sulthan (2006) in determining the contrast value.

Ilyas contrast is defined as follows:

$$C = \frac{B_{image}}{B_{sky}}$$

Schaefer contrast is defined as follows:

$$C = \frac{|B_{source} - B_{sky}|}{B_{sky}}$$

Sulthan contrast is defined as follows:

$$C = \frac{(B_{source} - B_{sky})}{B_{sky}}$$

There are similarities in the concepts used by the three researchers, namely comparing the brightness of the new moon with the background sky, similar to the definitions of Weber and Michelson. Therefore, in this study the authors used two mathematical definitions of contrast to determine the comparison of hilal contrast values in observations with infrared filters and without infrared filters.

Infrared is an electromagnetic wave that has a longer wavelength than visual light. Infrared waves have a wavelength range from 700 nm to 1 mm. With a wide coverage, infrared waves are divided into 3 regions, near-infrared, mid-infrared, and far-infrared. In this research, a near-infrared filter is used by considering the limit of the human eye (visual wavelength).

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 3 Human Eye Visual Wavelengths

Method

The method used in this research is direct observation made by the author at the Falak Science Observatory of Universitas Muhamamdiyah Sumatera Barus Branch. Observations used instruments available at OIF Barus, after the image was obtained then the author processed the data to get the brightness value of the image. The details of the instruments used are as follows:

Table 1: Observation Instrument

No	Instrument	Type
1	Telescope	William Optics Zenithstar 71 ED
2	Camera	ZWO ASI 120 MM
3	Mounting	Sky-Wacther HEQ 5 Pro
4	Filter	Baader IR-Pass Filter 685 nm
5	Laptop	Acer Aspire E 14

The author uses AstroImageJ software to analyze the brightness of the image that has been obtained. AstroImageJ is a Java-based image processing software that can determine the bright-dark level of an image photometrically (Collins, 2017). The author uses the aperture photometry method with sampling points at several points at the tip of the Moon's crescent and on the background sky in the area. After obtaining the brightness value of several points, the author analyzed the contrast value using Microsoft Excel. Using the Weber contrast and Michelson contrast equations to then compare between observations using filters and not using filters.

Result and Discussion

The author had difficulty in observing the young hilal that determines the beginning of the month using two different configurations, therefore for this study the author used an easier condition, which is when the old hilal is at noon. With relatively the same crescent shape but thicker so that the author averages the contrast value. Observations were made on February 18, 2023 at 10 pm or coinciding with 25 Jumadilakhir 1444 H.

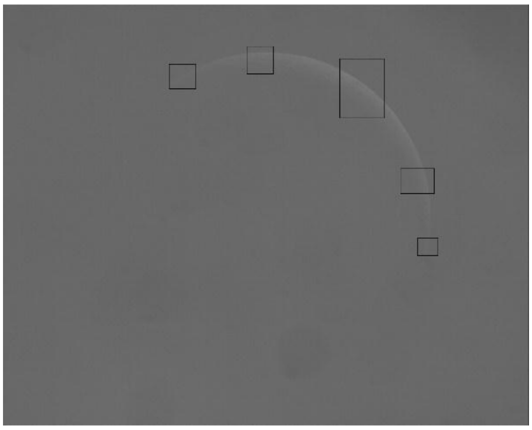

Figure 4: Hilal Image Using Infrared Filter

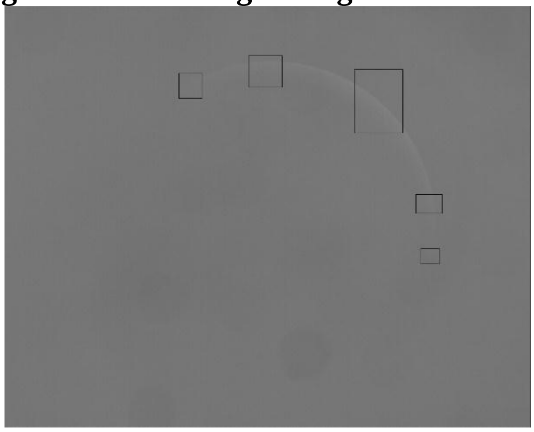

Figure 5: Hilal Image Without Infrared Filter

The author originally intended to take an image of the hilal in these two configurations using the same exposure setting. However, it turned out that if that was the case, the hilal would not be visible in one of the images. Therefore, the author used the auto setting in the Sharpcap software to get the right settings for each configuration. The result is that the filtered image uses an exposure of 2.5570 ms while the unfiltered image uses an exposure of 0.6840 ms.

The difference in exposure value has an impact on the amount of information captured by the camera. The longer the exposure, the more data is captured. This can be seen from the visual image of the hilal. It can be seen that the image of the hilal using a filter is clearer than without a filter.

Table 2: Brightness and Contrast Using Filter

No.	Hilal Brightness	Background Brightness	Weber Contrast	Michelson Contrast
1	838.7297	9.1132	91.03459817	0.978503
2	2000.5007	11.8939	167.1955204	0.988179
3	3106.5335	13.4189	230.5043334	0.991398
4	1745.4419	9.766	177.7263875	0.988872
5	862.6659	11.3854	74.76948548	0.973948
	Average		148.246065	0.98418

Table 3: Brightness and Contrast Without Filter

No.	Hilal	Background	Weber	Michelson

	Brightness	Brightness	Contrast	Contrast
1	308.3221	9.7079	30.75992	0.93895
2	1017.17	21.0728	47.26933	0.959407
3	1630.976	11.6015	139.5832	0.985874
4	1011.201	10.9394	91.43658	0.978595
5	391.2373	26.1674	13.95132	0.874619
	Average		64.60006	0.947489

Table 4: Contrast Comparison

Configuration	Weber Contrast	Michelson Contrast
Using filter	148.246065	0.98418
Without filter	64.60006	0.947489
Comparison	2.294828	1.038725

Conclusion

From the Weber contrast analysis with a 5-point sample on the crescent tip of the Moon with the background sky, the authors found an average improvement of 129%. While with the Michelson contrast analysis the authors get an average increase of 4%. From these two analyses, it can be concluded that using infrared filters in daylight hilal observations can significantly increase the contrast.

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