Kulminasi: Journal of Falak and Sharia
Vol. 2 No. 2 Desember 2024
DOI: 10.22373/kulminasi.v2i2.6046

Analysis Of Hilal Image Processing Method At Lembaga Falakiyah Nahdlatul Ulama Ponorogo

M. Zaidul Kirom[1], Unggul Suryo Ardi[2], Zahratul Fitria[3]
Universitas Islam Negeri Walisongo Semarang[1], Universitas Islam Negeri Sulthan Thaha Saifuddin Jambi [2], Institut Agama Islam Negeri Curup[3]
Email: zaiddull17@gmail.com[1], unggullegend@gmail.com[2], zahratulfitria1223@gmail.com[3]

Abstract: The Nahdlatul Ulama Branch Management Falakiyah Institute (LF PCNU) Ponorogo uses the image processing method in the rukyatul hilal process. By using this method, LF PCNU Ponorogo has succeeded in capturing the hilal image several times. This study aims to determine the characteristics of the LF PCNU Ponorogo image processing method for rukyatul hilal. This study is a Field Research category with a qualitative research type. Interviews and documentations are used for the data collection method. Furthermore, data analysis use descriptive analysis techniques and verification analysis. The primary data source in this study is the data that obtained in the field such as interviews and documentations. The secondary data is the data related to research such as image processing and astronomy books. The result of this study indicates that the application of the LF PCNU Ponorogo hilal image processing method for rukyatul hilal is processing on hilal images as verification of the existence of hilal in the image. The LF PCNU Ponorogo hilal image processing method has its own characteristics such as the use of video mode in capturing raw data to be processed by IRIS application.
Keywords: *Image Processing, Hilal, LF PCNU Ponorogo.*

INTRODUCTION

The image processing method is a technique in combining telescopes and digital cameras through a computerization process which is a very appropriate solution in the rukyatul hilal. In rukyatul hilal itself, image processing is a process to clarify the appearance of the hilal that has been captured by astrophotography techniques. Because the captured images often experience interferences, it is highly recommended to use the image processing method as hilal image processing so that the hilal will be visible and its appearance is believed.[1] Hilal image processing is needed to enhance crescent moon images for better identification.[2]

According to Hadi Bashori, rukyat that carried out using sophisticated equipment such as telescopes equipped with CCD Imaging needs to be reviewed and studied how the application of the two sciences combines rukyatul hilal with the development of science and technology.[3] Hilal (الهلال) etymologically means (غرّة القمر) the beginning of the month. This word is the musytaq of أهَلّ

[1] Unggul Suryo Ardi, *Karakteristik Metode Image Processing Untuk Rukyatul Hilal Studi Kasus di Dome Astronomi CASA PPMI Assalam, Solo,* Tesis Program Studi Magister Ilmu Falak, Fakultas Syari'ah dan Hukum, UIN Walisongo Semarang, 4. Ilmu Falak et al., "Tesis_1702048018_Unggul_Suryo_Ardi," 2019.

[2] Agus Andreansyah, "IDENTIFIKASI GARIS BATAS CITRA HILAL MENGGUNAKAN KERNEL MATRIKS," *Jurnal Disprotek* 14, no. 2 (2023): 156–65.

[3] Muh Bashori, "Hadi, Penanggalan Islam, Jakarta: PT," *Elex Media Komputindo*, 2013.

(rise) and أهِلّ (something visible). Hilal is the parameter for the beginning and end of a month in the Hijri calendar.[4] According to some scholars, the first visible form of the Moon is called the crescent moon/hilal because it appears after it was hidden or not visible. While others, it is called the crescent moon because when people see it, they raise their voices by reciting tahlil/yuhillu.[5] *Ahillah* in the plural indicates that the crescent moon does not form only once in one movement cycle. So Wahbah Zuhayli defines the new moon as the phase of the Moon's appearance that appears very thin on the first two or three nights at the beginning of each lunar month. Then the appearance of the Moon continued to increase until its light became perfect.[6]

Image processing is the processing of images using a computer that has better quality in recognizing objects.[7] Literally, what is meant by image is a picture that is in a two-dimensional plane. An image can be defined as a two-dimensional function f(x,y), where x and y are plane coordinates, and the value of the function f at each pair of coordinates (x,y) is called the intensity or gray level of the image at that point.[8] Based on this background, a problem criticism emerged in this study, namely the absence of a reference standard that can be used as a guideline in using the image processing method for rukyatul hilal, resulting in different data and accuracy at different locations. This study has a novelty, because the focus of this study is to examine the characteristics of the LF PCNU Ponorogo image processing method of hilal with its achievements to date, as well as its uniqueness in the very simple image processing process and its very simple instruments. The main problem in this study is to analyze the LF PCNU Ponorogo image processing method for rukyatul hilal.

RESEARCH METHOD

This study is a Field Research category with a qualitative research type. Interviews and documentations are used for the data collection method. Furthermore, data analysis use descriptive analysis techniques and verification analysis. The primary data source in this study is the data that

[4] M Hasan Faadillah and Mahasena Putra, "Measuring and Modelling Crescent Image Contrast with a DSLR Camera," *Al-Marshad: Jurnal Astronomi Islam Dan Ilmu-Ilmu Berkaitan* 9, no. 1 (2023): 91–101.

[5] Ahmad Junaidi, "Memadukan Rukyatulhilal Dengan Perkembangan Sains," *Jurnal Madania: Transformasi Islam Dan Kebudayaan* 22, no. 1 (2018): 145–58. Lihat juga Abu al-Qasim Ismail bin Ubbad bin al-Abbas bin Ahmad bin Idris al-Taliqani, *al-Muhith fi al-Lughah*, (Beirut:'Alim al-Kutub, 1994) vol. 3, 322.

[6] Wahbah Al-Zuhayli, *Al-Tafsir Al-Munir Fi Al-Aqidah Wa Al-Syari'ah Wa Al-Minhaj* (Dar al-Fikir, 2003).

[7] Dewi Permata Sari et al., "Identifikasi Huruf Braille Berbasis Image Processing Secara Real Time," *Jurnal Ampere* 2, no. 2 (2017): 68–80.

[8] Fajar Astuti Hermawati, "Pengolahan Citra Digital," *Yogyakarta. Penerbit: Andi*, 2013.

obtained in the field such as interviews and documentations. The secondary data is the data related to research such as image processing and astronomy books.

RESULT AND DISCUSSION

Astrophotography for Rukyatul Hilal

Astrophotography in rukyatul hilal has a very close relationship with hilal image processing techniques.[9] This technique enhances the visibility of the crescent moon using advanced optical and digital technologies. This technique aims to clarify the new moon's image, supporting objective observations for determining the beginning of the lunar month.[10] Image processing is the final part of astrophotography. Hilal image processing in rukyatul hilal aims to enhance image quality for better interpretation. It involves techniques like noise reduction, contrast and brightness adjustment, and color correction, essential for accurately confirming the new moon's existence while adhering to fiqh validity.[11] According to Achmad Junaidi image processing only applies to good images, while bad images cannot be saved by image processing in any way. A good image can be obtained with the best focus and a balanced composition of ISO (gain) and light exposure (shutter speed) settings on the camera. Image processing methods are divided into three types, namely:[12]

1. Complete image processing, image processing that uses corrections from dark frame, flat frame, and offset frame calibration images.
2. Semi-complete Image processing, only using one of the corrections from the three calibration images above.
3. Simple image processing, the light image is directly fixed by adjusting the contrast.

[9] 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 (2018).

[10] M Basithussyarop Basithussyarop, "PROBLEMATIKA ASTROFOTOGRAFI DALAM RUKYATUL HILAL," *ELFALAKY: Jurnal Ilmu Falak* 6, no. 1 (2022): 111–36.

[11] Riza Afrian Mustaqim, "TRANSFORMATION OF RUKYATUL HILAL METHOD (Postmodernism Analysis of Hilal Image Processing)," *Al-Hilal: Journal of Islamic Astronomy* 1, no. 1 (2019).

[12]Interview with Achmad Junaidi, on January 20, 2020, at the dormitory of UIN Walisongo Semarang.

Hilal Image Astrophotography at LF PCNU Ponorogo

The use of the image processing method at LF PCNU Ponorogo began in 2015, but had not yet achieved satisfactory results until 2018. The image processing method in Ponorogo was initiated by the Watoe Dhakon Observatory IAIN Ponorogo.[13] LF PCNU Ponorogo truly felt that it had mastered the image processing technique in 2019. The following is the crescent moon data that was successfully captured by LF PCNU Ponorogo using the image processing method since its use until now.[14]

Table.1

The results of rukyatul hilal LF PCNU Ponorogo using the image processing method[15]

Year	Hilal Visibility
1438	1
1439	1
1440	1
1441	1

Based on the table, LF PCNU Ponorogo has succeeded in obtaining the hilal image several times. In 1438 H. LF PCNU Ponorogo succeeded in capturing the hilal image in the month of Zulkaidah, in 1439 H. in the month of Zulhijah, in 1440 H. in the month of Zulkaidah and in 1441 H. hilal that was successfully captured was the hilal in the month of Muharam and the month of Safar. The results of the hilal images that successfully captured were immediately reported to the Falakiyah Institute of the Nahdlatul Ulama Executive Board (LF PBNU) and sometimes also

[13] Data diperoleh dari tanya jawab dengan Achmad Junaidi di aplikasi WhatsApp Rabu, 18 Desember 2019 pukul 13.25.

[14]Interview with Achmad Junaidi, on June 5, 2020.

[15] Data pengamatan hilal dapat dilihat pada laman "Crescent Observation Result" pada situs resmi ICOP milik Shawkat Audah, http://www.icoproject.org/res.html diakses pada 6 Juni 2020.

reported to the ICOP site owned by Shawkat Audah.[16] This data can be seen on the official ICOP website, where reports of new moon sightings from around the world are reported.

Figure 1. Image of the crescent moon of Zulkaidah 1438 H.

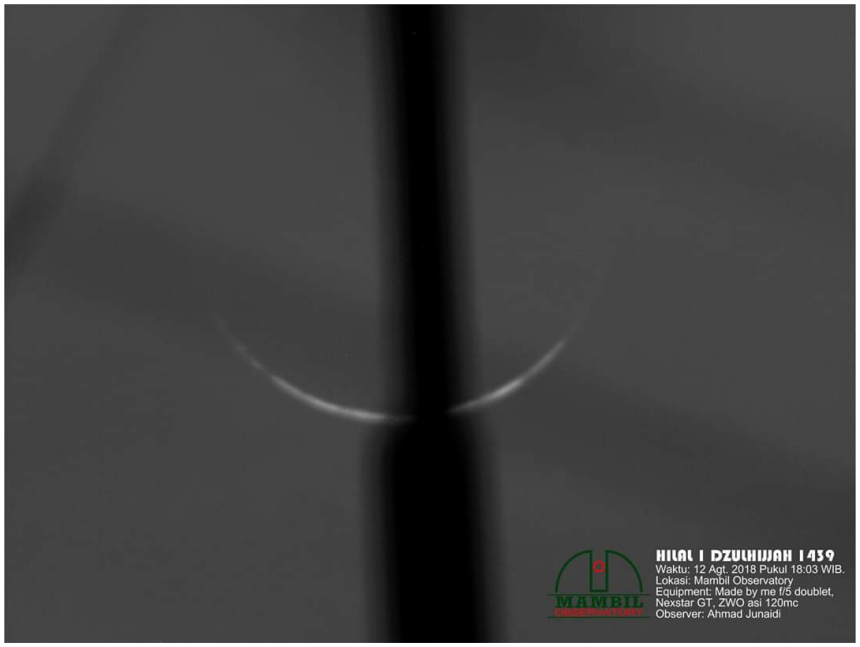

Figure 2. Image of the crescent moon of Zulhijah 1439 H.

[16]Islamic Crescent's Observation Object (ICOP) is a crescent moon research and observation institution founded by Muhammad Syaukat 'Audah or better known as Mohammad Shawkat Odeh. An astronomer who was born in Kuwait on March 6, 1979.

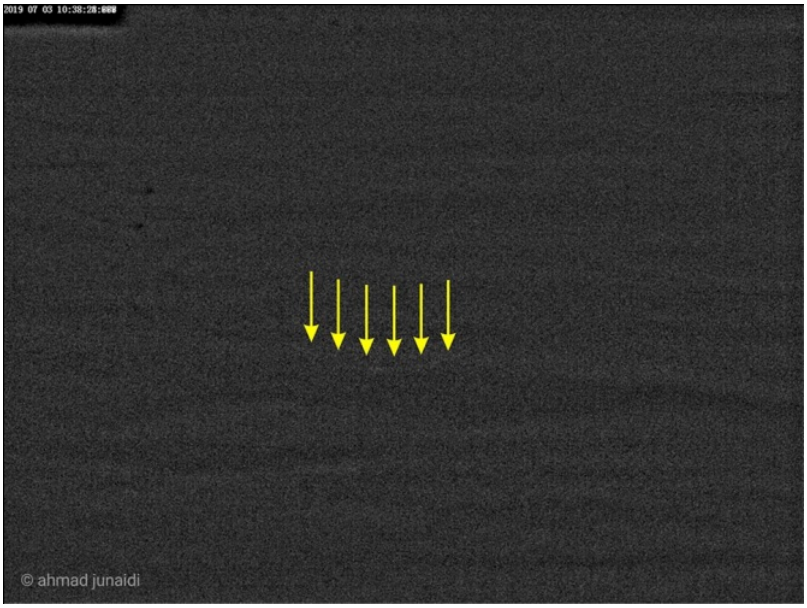

Figure 3. Image of the crescent moon of Zulqadah 1440 H.

Figure 4. Image of the crescent moon of Muharram 1441 H.

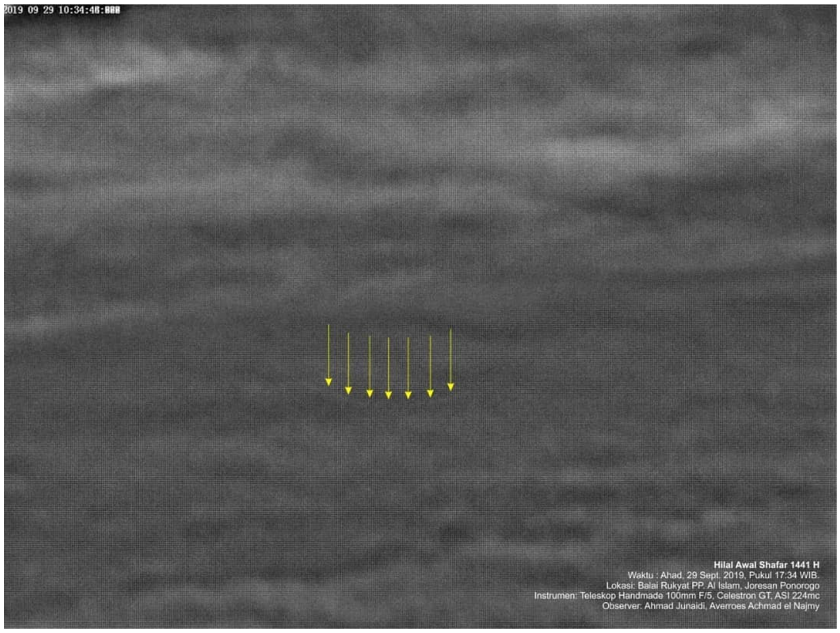

Figure 5: Image of the crescent moon of Safar 1441 H.[17]

Hilal image processing in rukyatul hilal involves using astro digital imaging to enhance objectivity in determining the lunar month. This technology provides corroborative evidence, reducing subjectivity in witness testimonies, and aligns with fiqh principles regarding the acceptance of evidence.[18] LF PCNU Ponorogo uses a Handmade Refractor telescope for rukyatul hilal.[19] The operation of this telescope is basically same as a refractor telescope in general, using a combination of two objective lenses, where the main lens as a collector of shadows and light is then forwarded to the eyepiece to be displayed to the eye as a shadow of an object.[20] The use of refractor telescopes aims to bend or refract light. Then Refraction causes parallel light rays to gather at the focal point. Then the telescope converts parallel rays by making an alpha angle with the optical axis for a second set of parallel rays with a beta angle. The ratio of beta to alpha is called the magnification angle. This thing is same as the comparison between the size of the retinal image obtained with or without a telescope.[21] The consideration of LF PCNU Ponorogo in choosing and

[17] Semua Gambar diperoleh dari Achmad Junaidi Sekretaris LF PCNU Ponorogo.

[18] Ahmad Junaidi, "Syahadah Rukyatulhilal Using Astro Digital Imaging: From Subjectivity to Objectivity," *De Jure: Jurnal Hukum Dan Syar'iah* 14, no. 1 (2022): 58–74.

[19] Refractor or dioptric is a type of telescope that only uses lenses to display the image of an object. Read, Siti Tatmainul Qulub, "Ilmu Falak Dari Sejarah Ke Teori Dan Aplikasi," *Depok: Rajawali Pers*, 2017, 18–22.

[20] Qulub.

[21] Qulub.

using the Handmade Refractor telescope because there is the limit of its ability in terms of funds. The telescope is a telescope that is assembled by itself starting from the stage of searching for used equipment with a much cheaper price such as photocopy lenses and projector lenses, although there are those who sell special telescope lenses which of course are much more expensive.[22]

LF PCNU Ponorogo tends not to use diagonal mirrors to connect the CCD lens to the telescope. Because the astronomical camera it has when connected to the objective lens, the object is automatically not inverted. In addition, according to Achmad Junaidi, the use of diagonal mirrors made of poor quality materials has the potential to reduce the contrast captured.[23] The next important part for rukyatul hilal using the image processing method is mounting.[24]on the telescope. The mounting used by LF PCNU Ponorgo is the American-made Celestron Alt-Azimuth mounting. This mounting was also purchased at a relatively much cheaper price because it was an incomplete used tool and was modified again by Achmad Junaidi at a cost of only 2 million rupiah. Although in its use, the equatorial mount type mounting[25] more stable than Alt-Azimuth mounting[26], but the mounting of LF PCNU Ponorogo is quite good in terms of tracking capabilities[27]and the object does not shift. The reason for choosing this mounting is also because that is the limit of the cost capability, because to buy the cheapest mounting alone it costs around 6 million rupiah.

The type of CCD used by LF PCNU Ponorogo is ZWO ASI224MC. The reason for choosing this astronomical camera is also because it is only capable of this much in terms of cost. The ZWO ASI224MC astronomical camera is an inexpensive astronomical camera, but not the cheapest. And the most important thing in choosing the type of astronomical camera is understanding the performance of the sensor in the camera. According to Achmad Junaidi, ZWO

---

[22] Interview with Achmad Junaidi, on June 5, 2020.

[23] Charge Couple Device (CCD) is the mainstay celestial object image detector in astronomical observation and has been installed on almost all telescopes in observatories around the world. This is due to the CCD's better detection capability compared to other image detectors and its measurement results are quantized so that they can be processed on a computer. Read, Taufiq Widjanarko, "Andrianto Handojo, Dan Hakim Luthfi."," in *Deskripsi Kinerja Dan Pengujian Sistem Kamera CCD Hamamatsu", Disajikan Sebagai Makalah Pada Seminar Sehari Astronomi Di ITB Bandung,* 1995.

[24]Mounting is a robotic machine on the telescope that moves the telescope and is operated by remote.

[25] Equatorial Mount is a mounting designed with a rotating motion parallel to the Earth's axis of rotation. Read Siti Tatmainul Qulub, *Ilmu Falak*, 289.

[26]Alt-azimuth Mounting is designed with its movement limited to up, down, left and right. Interview with Achmad Junaidi, on June 5, 2020 via telephone.

[27]Tracking is the process of tracking a telescope against a celestial object.

ASI224MC has a fairly good performance sensor for rukyatul hilal. The stages of CCD operation are as follows:[28]

1. First point the telescope at a specific object, then focus.
2. Plug in the ZWO ASI224MC input cable and then connect it to the PC using a USB cable.
3. The next step is to operate the CCD via PC. At this stage, the CCD driver and SharpCap application must be installed first on the PC. Then open the Sharpcap application.
4. The principle of recording using this software is by taking as much data as possible starting before sunset. Every 2 seconds of crescent image recording produces 50 image frames, so to minimize the image capacity on limited storage memory, recording is done periodically for 2 seconds and pause for a while before recording again for 2 seconds, and so on until the end of the crescent sunset.

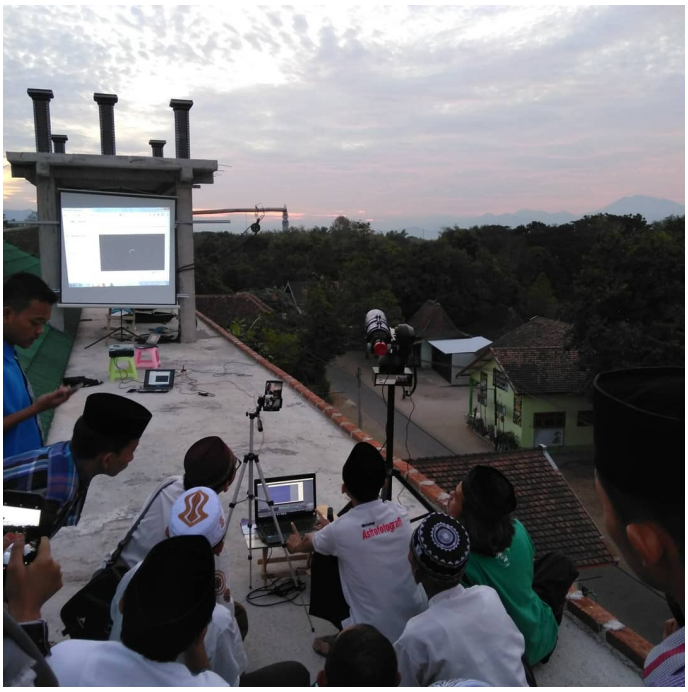

Figure 6: Achmad Junaidi is operating the ZWO ASI224MC to record the crescent moon image.[29]

[28]Interview with Achmad Junaidi, on June 5, 2020 via telephone.

[29] Gambar diperoleh dari Ustad Abdani Fauzi, salah seorang tenaga pengajar Pondok Pesantren Al-Islam Joresan.

Hilal Image Analysis

The next process is image processing which aims to strengthen the weak image signal so that the eye can see it. Applications used in LF PCNU Ponorogo processing such ShrapCap[30] The LF PCNU Ponorogo image processing method has several characteristics of its own. The main uniqueness characterizes of LF PCNU Ponorogo is the experts of this institution buy and prepare the instruments needed for the image processing method themselves without being facilitated by the institution, but their use is still used together for LF PCNU Ponorogo for the benefit of the people. This can be seen from the instruments used by LF PCNU Ponorogo.[31] First, this institution uses a Handmade Refractor telescope. As Achmad Junaidi said, the use of the Handmade Refractor telescope at LF PCNU Ponorogo is caused there is the extent of its ability to buy a telescope. In addition, no matter how good the telescope is, if it does not master the focusing technique properly, the image still cannot be processed.

Second, LF PCNU Ponorogo uses an astronomical camera in its image processing method, namely a CCD sensor as an acquisition sensor to capture the crescent image. The CCD used by LF PCNU Ponorogo is the ZWO ASI224MC. The use of this CCD is because the ZWO ASI224MC has quite good performance for rukyatul hilal and can be purchased at a cheaper price compared to other CCD models. Third, LF PCNU Ponorogo uses an American-made Celestron Alt-Azimuth type mounting. Celestron Alt-Azimuth mounting is a characteristic of LF PCNU Ponorogo because this type of mounting is designed with movements that are only limited to up, down, left and right, besides that the mounting is a used mounting that has been modified by Achmad Junaidi. While in several institutions that have image processing methods such as BMKG and CASA[32], the mounting used is an equatorial mount type mounting designed with a rotating motion parallel to the Earth's axis of rotation. In the future, when LF PCNU Ponorogo is established in terms of funding, LF PCNU Ponorogo can upgrade the instruments needed in the image processing method, so that it will be more established in performing image processing.

[30]SharpCap is an application used to operate CCD on a PC. The advantages of this software are free download and easier and universal for CCD and CMOS.

[31]Interview with Achmad Junaidi, on June 5, 2020 via telephone.

[32]CASA stands for Club Astronomy Santri Assalam which was founded by AR Sugeng Riyadi and Budi Prasetyo in the Assalam Islamic Boarding School, Solo. CASA routinely carries out rukyatul hilal every month and is also supported by image processing technology. Read, Unggul Suryo Ardi, Characteristics of Image Processing Methods for Rukyatul Hilal Case Study at Dome Astronomy CASA PPMI Assalam, Solo, Thesis of the Master of Astronomy Program, Faculty of Sharia and Law, UIN Walisongo Semarang, 55-57.

Figure 7: Handmade Refractor Telescope that has been connected to the ZWO ASI224MC astronomy camera and Colestron Alt-Azimuth mounting.[33]

The selection of observation sites is also a characteristic of LF PCNU Ponorogo. Different locations will affect different accuracy in the use of image processing technology for rukyatul hilal. In this case, LF PCNU Ponorogo chose the Ibnu Syatir Rukyat Hall at the Al-Islam Islamic Boarding School, Joresan. According to Achmad Junadi, this Rukyat Hall has a fairly good yard for rukyatul hilal activities. This can be seen from the condition of the western horizon when viewed from the Ibnu Syatir Rukyat Hall, the western horizon is free from fog and reflection of refracted sunlight and is not too cloudy.[34]

In the process of processing the crescent moon image, LF PCNU Ponorogo uses the same application as that used by astronomers in general, namely the IRIS application. There are two processing models in IRIS, namely stacking in video mode and calibrator images in photo mode. In using the stacking method, LF PCNU Ponorogo chooses the "Arithmatic" option in the

[33] Gambar diperoleh dari Achmad Junaidi Sekretaris LF PCNU Ponorogo.

[34] Interview with Achmad Junaidi, on June 5, 2020 via telephone.

stacking or "add a sequence" window. According to Achmad Junaidi, the option to choose "Arithmatic" is because the processing of the crescent moon image is done by stacking images, for example 50 image frames are stacked, then the 50 image frames will be stacked without being reduced, so LF PCNU Ponorogo tends to use the "Arithmatic" option. Not all astronomers use the "Arithmatic" option in the stacking window, as in CASA who prefer the "Median" option on the grounds that the processing processed by IRIS will be more focused on the crescent moon.[35]However, after using IRIS, CASA still needs additional software such as GIMP, while LF PCNU Ponorogo only needs IRIS to capture the crescent image. According to Achmad Junaidi, using the "Median" option will equalize the captured image frames. For example, from 50 image frames, the middle value will be taken so that it requires the strongest contrast from the 50 image frames.[36]

The author found that there are three types of image processing used in the LF PCNU Ponorogo image processing method, namely complete image processing which requires offset images, dark images and flat images as calibration images, semi-complete image processing which is processed only by adding flat images for hilal image calibration, and simple image processing which is sufficient by processing hilal images only. The use of the three image processing methods is adjusted to the needs based on weather conditions in the field during rukyatul hilal. However, in practice, LF PCNU Ponorogo more often uses the simple image processing method because of the urgent need for reporting rukyatul hilal results. This method is characteristic of LF PCNU Ponorogo which does not require a long time to process hilal images so that the reporting must be expedited for the benefit of the community.[37]

CONCLUSION

This study found that the LF PCNU Ponorogo image processing method has its own characteristics, according to the author in terms of instruments, LF PCNU Ponorogo is an institution that has an image processing method with simple tools and can be purchased at an economical price. This can be seen from the instruments used by LF PCNU Ponorogo. First, in the Nahdlatul Ulama organization, the nature is struggling so that all needs in terms of instruments

[35]Unggul Suryo Ardi, Characteristics, 89.

[36]Interview with Achmad Junaidi, on January 20, 2020, at the dormitory of campus 1 UIN Walisongo Semarang.

[37]Interview with Achmad Junaidi, on January 20, 2020, at the dormitory of campus 1 UIN Walisongo Semarang.

are purchased and equipped by the LF PCNU Ponorogo administrators personally. Second, this institution uses a telescope that is assembled by itself or commonly called a Handmade telescope, this type of telescope is a refractor.

Third, this institution uses an American-made Colestron Alt-Azimuth mounting that is designed to only be able to move up, down, left and right. This mounting has also been modified, because it was purchased second-hand for 1.8 million rupiah so that its is lack of completeness. This mounting is very cheap because the modification cost only costs around 200,000 rupiah, while to buy the cheapest mounting, it will cost around 6 million rupiah. Fourth, this institution uses CCD as an image acquisition sensor, ZWO ASI224MC. This sensor records the crescent image and saves it in video mode with AVI format. Fifth, LF PCNU Ponorogo uses SharpCap software to set the CCD to record images and save the images files to a PC.

Then the software for image processing is IRIS. Image processing on IRIS is divided into three types according to observer needs such as complete image processing that requires calibration images for example bias, dark and flat, semi-complete image processing that is calibrated only by adding flat images, and simple image processing that does not use calibration images. In the stacking process, LF PCNU Ponorogo uses the "Arithmatic" option to stack frames without reducing the image frame.

BIBLIOGRAPHY

Al-Zuhayli, Wahbah. *Al-Tafsir Al-Munir Fi Al-Aqidah Wa Al-Syari'ah Wa Al-Minhaj*. Dar al-Fikir, 2003.

Andreansyah, Agus. "IDENTIFIKASI GARIS BATAS CITRA HILAL MENGGUNAKAN KERNEL MATRIKS." *Jurnal Disprotek* 14, no. 2 (2023): 156–65.

Bashori, Muh. "Hadi, Penanggalan Islam, Jakarta: PT." *Elex Media Komputindo*, 2013.

Basithussyarop, M Basithussyarop. "PROBLEMATIKA ASTROFOTOGRAFI DALAM RUKYATUL HILAL." *ELFALAKY: Jurnal Ilmu Falak* 6, no. 1 (2022): 111–36.

Faadillah, M Hasan, and Mahasena Putra. "Measuring and Modelling Crescent Image Contrast with a DSLR Camera." *Al-Marshad: Jurnal Astronomi Islam Dan Ilmu-Ilmu Berkaitan* 9, no. 1 (2023): 91–101.

Falak, Magister Ilmu, Program Pascasarjana, Universitas Islam, and Negeri Walisongo. "Tesis_1702048018_Unggul_Suryo_Ardi," 2019.

Hermawati, Fajar Astuti. "Pengolahan Citra Digital." *Yogyakarta. Penerbit: Andi*, 2013.

Junaidi, Ahmad. "Memadukan Rukyatulhilal Dengan Perkembangan Sains." *Jurnal Madania: Transformasi Islam Dan Kebudayaan* 22, no. 1 (2018): 145–58.

———. "Syahadah Rukyatulhilal Using Astro Digital Imaging: From Subjectivity to Objectivity." *De Jure: Jurnal Hukum Dan Syar'iah* 14, no. 1 (2022): 58–74.

Mustaqim, Riza Afrian. "Pandangan Ulama Terhadap Image Processing Pada Astrofotografi Di BMKG Untuk Rukyatul Hilal." *Al-Marshad: Jurnal Astronomi Islam Dan Ilmu-Ilmu Berkaitan* 4, no. 1 (2018).

———. "TRANSFORMATION OF RUKYATUL HILAL METHOD (Postmodernism Analysis of Hilal Image Processing)." *Al-Hilal: Journal of Islamic Astronomy* 1, no. 1 (2019).

Qulub, Siti Tatmainul. "Ilmu Falak Dari Sejarah Ke Teori Dan Aplikasi." *Depok: Rajawali Pers*, 2017, 18–22.

Sari, Dewi Permata, Sabilal Rasyad, Evelina Evelina, and Amperawan Amperawan. "Identifikasi Huruf Braille Berbasis Image Processing Secara Real Time." *Jurnal Ampere* 2, no. 2 (2017): 68–80.

Wawancara dengan Achmad Junaidi, sebagai Sekretaris LFNU Ponorogo, pada 18 Desember 2019, via WhatsApp.

Wawancara dengan Achmad Junaidi, sebagai Sekretaris LFNU Ponorogo, pada 20 Januari 2020, di wisma kampus 1 UIN Walisongo Semarang.

Wawancara dengan Achmad Junaidi, sebagai Sekretaris LFNU Ponorogo, pada 5 Juni 2020, via telepon.

Widjanarko, Taufiq. "Andrianto Handojo, Dan Hakim Luthfi."." In *Deskripsi Kinerja Dan Pengujian Sistem Kamera CCD Hamamatsu", Disajikan Sebagai Makalah Pada Seminar Sehari Astronomi Di ITB Bandung*, 1995.