


The Application of Image Processing Techniques for Hilal Detection in Indonesia and Their Limitations

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| Article Info | ABSTRACT |
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| <p>Article History Received 04-03-2025 Revision 08-05-2025 Accepted 26-05-2025</p> | <p>The practice of hilal rukyat is closely associated with the utilization of Image Processing, as the hilal images captured are frequently degraded. This degradation renders image interpretation more challenging, as the information contained within the image is diminished. Consequently, Image Processing is essential for enhancing the quality of such images. However, there are limitations to the application of this technique, as various Image Processing methods can be categorized as object manipulation. Employing a qualitative library research approach, the study analyzes existing literature and expert opinions to assess the acceptability of such techniques. From the research conducted, it has been ascertained that Image Processing techniques employed in hilal rukyat can enhance the visual appearance of the hilal. Nevertheless, if the actual hilal is not discernible, it is processed to render it visible, which is not accepted as it is considered engineering. Image Processing can serve as a tool to facilitate observation and augment the likelihood of the hilal being observed. The clarified image of the hilal is acceptable, thereby enabling this technique to be considered as part of rukyat bil fi'li. Rukyat bil fi'li involves direct observation with the objective of clarifying the existing hilal, not the creation of an invisible hilal.</p> |
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I. Introduction

As a result of hilal imagery often experiencing degradation, the practice of rukyatul hilal is closely related to image processing activities. Image processing can be understood as a method of transforming an image into a more desirable or optimal representation. In essence, image processing involves an input process that transforms an image into an output image that aligns with the desired outcome.[8] Low image contrast has become an obstacle in hilal observation.[1] Especially the hilal that is less than 20 hours old, the area of light and light is very thin and weak.[2] This kind of image becomes more difficult to interpret because the information contained in the image is reduced.[3] For this reason, image processing is necessary to improve the image.[4] Using this technique, hilal research at Bosscha Observatory successfully observed hilal with an elongation below 4 degrees,[5] more precisely at an elongation of 3 degrees 40 minutes of arc. The observatory team also managed to observe hilal with illumination below 0.1%.[1] Therefore, Image Processing becomes very important in hilal rukyatul activities because it can help clarify the image and increase contrast so that the resulting hilal image can provide accurate and reliable information.

The application of Image Processing techniques is also a separate study in the realm of astrology. Some of these studies include trying to explain how the scholars view the use of Image Processing techniques in rukyatul hilal activities.[4] There are also related writings that try to examine some problems related to this matter such as witnesses with the help of technology.[6] From these writings, it can be seen that there are still many differences of opinion regarding this matter. The differences are related to the limits of the use of Image Processing techniques in the practice of rukyatul hilal. For this reason, the limitations need to be studied further.

This paper aims to examine image processing techniques used in hilal detection and the limitations of using these techniques, which may contribute as empirical evidence in the process of crescent moon (hilal) identification.[7] The author's initial hypothesis is that there are some limitations to the use of image processing techniques in hilal rukyatul, seeing that there are so many types in the field with various concepts, some of which already fall into the category of object manipulation. Therefore, such limitations need to be applied.

II. Method

This research is a category of library research with the type of research as qualitative research. In this paper, the desk research method is used to analyze and understand the topic discussed. The research process begins with the collection of secondary data from various relevant written sources, including books, scientific journals, articles, and official documents. The information obtained from these sources is then categorized and analyzed to identify significant patterns, trends, and perspectives related to the study topic. The results of this analysis are integrated to build the theoretical framework underlying the arguments in this paper, as well as to provide empirical support for the proposed hypotheses. Using this

method, this paper aims to enrich the understanding of the topic under study and make a meaningful contribution to the existing literature.

III. Results and Discussion

Image Processing Theory

a. Image Processing

The first digital image processing was recorded in early 1921, when a photograph was successfully transmitted digitally via sea cable from New York City to London (Bartlane Cable Picture Transmission System). The photo was sent in the form of a digital code which was then converted back using a telegraph printer on the receiving end. This method succeeded in shortening the time of sending photos from about a week to less than 3 hours. The year 1960 was noted as the year when this method developed rapidly.[7]

Processing according to the Big Indonesian Dictionary (KBBI) is defined as a way or a process of trying something to become different or become more perfect. While the image according to KBBI is defined as a likeness or image, in this case is an image obtained using a visual system. Overall, image processing can be interpreted as a way to change an image into a more perfect or desired image. In other words, image processing is an image input process which then produces an output in the form of an image as desired.[8]

An image according to Webster's dictionary is a representation, likeness or imitation of an object. For example, the image of a house represents the identity of the house in front of a camera. An image can also be said to be the distribution of dark-light, dim-light, and/or colorful variations on a flat plane. Images can be the result of painting, photography, or drawings and doodles done on paper, canvas, and on monitor screens.[8] There are three display formats to represent digital images, namely [7]:

1. Color Image

Color images are generally formed from three channels of red (R), green (G), and blue (B) color components that are modeled into the RGB color space. RGB is the standard for displaying color images on television screens and computer screens. Besides that, there are also images that use a different color space from RGB, such as HSV (hue, saturation, value), CMYK (cyan, magenta, yellow, and black) RGB and alpha (A) as a color image with transparency modeled in RGBA color space, and others.[9]

2. Grayscale Image

Grayscale images represent digital images using a scale of intensity values, known as gray degrees.[10] The degree of gray is the result of lifting the bit value to the number $2^{(2n)}$. Suppose a 4-bit gray scale has a gray scale range of 16 colors, which are represented by the numbers 0 to 15. The number 0 or the minimum value represents black, and the number 15 or the maximum value represents white. Meanwhile, the numbers between 0 and 15 display the gray color in the form of different brightness scales.[7]

3. Binary Image

Binary images or black and white images where each of these two colors is represented by a binary number (0 and 1).[7] A value of 0 will appear as black and 1 will appear as white. Thus, a binary image has 2 possible values for each pixel, namely 0 or 1. A binary image is obtained by thresholding the grayscale image.[10] Thresholding is a step in processing to reach the threshold of a grayscale image to get a binary image (black and white).

Generally, operations in Image Processing are applied to images when:

1. Enhancement or modification of an image that aims to improve its viewing quality or to highlight some aspect of the information contained in the image.
2. Elements within the image need to be grouped, matched, or measured.
3. Parts of the image need to be merged with other parts of the image.

Image processing is broadly grouped into 2 types of activities:[8]

1. Improving the image quality to make it easier to interpret.
2. Processing information on an image for a desired purpose is usually to recognize the pattern of an object.

The second application relates to pattern recognition, which is useful for recognizing an object. This is done by extracting important information contained in an image. Pattern recognition is part of the final stage of image processing, namely image analysis. Through this stage, it is expected to form a system that can process and recognize input image patterns directly.[8]

In general, the stages of digital image processing include several stages, namely[8]:

1. Image acquisition

Image acquisition serves to capture, collect and prepare image data using image recording tools and process it to produce the desired data. Images can be recorded using tools such as video cameras, conventional cameras, digital cameras, scanners and others. If the resulting image is still in analog form, it needs to be digitized using a digitizer.

2. Image quality improvement

The image enhancement stage is also known as the pre-processing stage. In this stage, brightness enhancement, contrast modification, noise removal, geometry transformation, and determination of image parts needed for further processing are performed. The purpose of this stage is to increase the likelihood of success in the next stage of image processing.

The image restoration stage is different from the image enhancement stage. The image enhancement stage is more subjective, meaning that it is more influenced by human will, while the image restoration stage is objective, which tends to be based on probability or mathematical models of image degradation. This means that image restoration aims to restore the image to its original image.

Color image processing, wavelet, compression and morphological processing are important processes in image processing. Nowadays, almost all image information exchange and image engineering use color images. The consequence is that it

involves a large data size because to encode 1 pixel of the image requires a long bit while currently the image size has become very large up to the order of Mega pixels. To overcome this problem, one solution is to use compression methods. One method that can be used for compression is using wavelets. Morphological processing views the image as a set and is usually used in binary images.

3. Image segmentation

The image segmentation stage is an advanced stage in image processing. The purpose of this stage is to divide the image into key parts that contain important information, an example of its application is to separate objects from the background. Automatic image segmentation is the most difficult task in digital image processing. The accuracy of the image segmentation process will affect the success of the object recognition task.

4. Representation and description, recognition and interpretation.

The representation and description stage follows the output of the segmentation stage, which is usually raw image data that represents one of the boundaries of a region. This image data is a series of closed curve coordinate points with a description of the area and its parameters. The next process is feature detection and feature extraction, the results of which can be used for the final process of image processing, namely image analysis.

b. Components of Image Processing

In general, as described by Bernd Jahne, image processing and acquisition systems consist of four important components :[9]

1. Image acquisition system. Systems that can be used include CCD cameras, flatbed scanners, or video recorders. A digital camera is one of the components in an image processing system. It is included in the image sensor, where there is a sensor that produces electrical output proportional to light intensity and there is also a digitizer that converts electrical output into digital data. However, digital images can be obtained not only using devices that use light intensity capture sensors but images can also be obtained using other sensors, such as Gamma Rays, X-rays, Ultraviolet, Infrared, Microwaves, Radio-Frequency Fields, Ultrasonic, and others.[8]
2. A device known as a frame grabber for converting electrical signals (usually analog video signals) from an image acquisition system into digital images that can be stored.
3. A computer, in an image processing system, is a computer that has the ability to perform image processing.[11] Software for image processing consists of specialized modules to perform specific tasks. It is also designed to have the ability for users to write their program code using special modules.[8]
4. Image processing software that provides tools or applications for manipulating and analyzing images.

Use of Image Processing Techniques in Rukyatul Hilal

There are 4 *Images Processing* methods in astrophotography that are commonly used for hilal rukyatul[4], namely:

1. Increase or decrease the contrast of a downstream image.
Contrast is the visual ratio of different shades in an image. It is this difference that creates texture, highlights, shadows, color, and clarity in a photograph. Contrast makes objects in an image distinguishable.[12] Contrast is determined by the difference in color and brightness of objects from one another within the same field of view.[13]
Contrast is needed in hilal images to clarify its appearance, which often looks the same as the background or other objects such as clouds around it. Contrast enhancement is needed to make the hilal clearer and more dominating so that the observer can confirm that the object in the image is the hilal. So, in the practice of contrast enhancement in this rukyah need, basically the initial image of the hilal has been seen or visible, the contrast enhancement is done to further clarify the hilal that has been detected.[4]
2. Increase or decrease the contrast of some hilal images with respect to their consistency.
The contrast function remains the same in this stage. However, what distinguishes this stage from the previous stage is that the hilal in this stage has not been confirmed to be visible or not, but the possibility of being visible exists, so processing on one image of the hilal alone will not help. Another thing that needs to be done is to pay attention to the consistency of hilal visibility in other images. Consistency means that there are similarities between one image and another, both in terms of the shape of the hilal, and in terms of the position or location of the hilal in one image and another. If the consistency shows similarities, then it can be concluded that what looks like hilal is hilal. In the process, the contrast is increased on some images to further confirm that the hilal image is indeed visible.
3. Stacking hilal images without calibration.
Unlike the previous stage, at this stage the hilal is not visible in some images. And contrast enhancement in a single image or contrast enhancement in multiple images with respect to their consistency does not help to display the hilal image in the image. So the next possible step is to overlay multiple hilal images or merge multiple images into one. The buildup is not limited to 100 images or even more. The stacked images will display the final hilal image, so that it can be confirmed whether the hilal is visible or not. If the hilal image is visible, then a hilal shape will appear at the same place and position in the stacked images.
4. Stacking hilal images with calibration.
In the last stage, the process is almost the same as the third stage, which is stacking several hilal images into one image to determine whether the hilal is visible or not. However, what distinguishes it is that in this fourth stage before stacking, first calibrate the hilal image. The calibration is done during image capture with calibrator tools. To improve the Signal to Noise (S/N) Ratio, record bias frames, dark frames, and flat field frames. Bias Imagery is required to correct the irregularity of each pixel on the detector in recording data. Dark Image is needed to correct the effects of heat and electronic noise on the detector. Flat Field Imagery is needed to correct problems related to the propagation of light from the front of the telescope, the lens, to the detector.[4]

In practice by several hilal observation organizers in Indonesia, several image processing techniques are used, among others:

1. The Meteorology, Climatology and Geophysics Agency (BMKG). The technique used by BMKG is very simple, just by adjusting the level and contrast of the image.[14]
2. National Institute of Aeronautics and Space (LAPAN). The technique used by LAPAN is relatively simple using the help of software called Adobe Photoshop. where the processing is done is to adjust the level, contrast, brightness, and white balance of the image.[14]
3. Imah Noong. Using the help of a software called Iris, the technique used by Imah Noong mainly consists of two stages, namely image cleaning and stacking. This technique aims to clarify and sharpen the image.[14]
4. CASA astronomy dome. The technique used is generally similar to that of Imah Noong, where the images that have been taken by the team are processed using stacking techniques in IRIS[9] and then further clarified using GIMP software.[9]

Limitations of Image Processing Techniques in Hilal Rukyatul

In some conditions image processing techniques are indispensable when searching for moon sightings. However, the use of this technique cannot be done arbitrarily. In this case, Thomas Djamaluddin argues that in rukyatul hilal image processing is positioned as a tool to increase confidence. This is similar to the use of a clock to ensure the entry of prayer time or the use of a compass to ensure the Qibla direction. The use of Image Processing in rukyatul hilal activities is a scientific effort to clarify the image of the hilal by removing the effects of interference and increasing the contrast, so that the observer can be sure that the recorded object is the hilal.

In terms of the application of Image Processing in rukyatul hilal activities, it must be understood that rukyatul hilal activities are a way that aims to ensure that the moon has changed with evidence of the sighting of the hilal. As evidence, hilal can be obtained by direct observation either without tools or with tools (such as kacamara, binoculars, telescopes), recording with a camera without the need for or with image processing.[4] The results of direct observation can be confirmed by oath, as for the image can be used as material evidence that can be a strong basis for the judge in the decision in the isbat session.[14]

The limitation of using Image Processing techniques according to Slamet Hambali is that the hilal needs to be seen first, even if it is unclear or faint. Image processing is allowed only to clarify the appearance of the hilal. However, if the actual hilal is not visible and then processed so that it appears to exist, this is unacceptable because it is potentially a fabrication. Therefore, to avoid mudharat, it is best not to rely on processes that may cause doubt. Hilal that is processed to clarify the image is considered valid, so Image Processing can also be considered as a form of rukyat bil fi'li. Rukyat bil fi'li is direct observation, not just based on scientific knowledge, because image processing only aims to clarify the existing hilal, not create a new hilal. Engineering, in this context, means changing something into another form or creating something that does not exist into

existence, which is impossible to do because in practice image processing is done in public.[15]

The main purpose of rukyat bil fi'li is to obtain evidence of the hilal, and the use of tools such as astrophotography and Image Processing can provide more accurate results. Image Processing is considered equivalent to rukyat bil fi'li, providing even stronger evidence. The difference lies in the way the evidence is obtained: the evidence of rukyat bil fi'li is stored in the observer's memory and declared orally before the judge under oath, whereas the evidence of Image Processing can be displayed on a screen or printed for the judge's verification. Although image evidence from Image Processing is very strong, there is a possibility of errors in interpretation, such as misidentifying streaks of light as hilal. This error can be avoided by comparing the results with a model of the hilal shape using an astronomy application such as Stellarium. Data from Image Processing can be used in hilal research and is more useful than rukyat bil fi'li evidence based solely on oaths, as image data can be stored for a long time for further research.[4]

IV. Conclusion

Based on the explanations presented in this study, it can be concluded that image processing techniques play a significant role in enhancing the effectiveness of rukyatul hilal (crescent moon observation) activities in Indonesia. Various methods, such as contrast enhancement, image stacking with and without calibration, and consistency analysis across multiple frames, are employed to clarify the visibility of the crescent in visually challenging conditions. These techniques have proven effective in assisting observers to distinguish the crescent from surrounding elements such as clouds or visual noise. However, clear boundaries must be maintained regarding their use. Image processing is permissible only when it is applied to enhance an already existing, albeit faint, crescent—not to fabricate or create a crescent that was not initially visible. Any manipulation that leads to the appearance of a previously unseen crescent is considered artificial and thus unacceptable as valid observational evidence. Therefore, processed images must be based on the real presence of the crescent to be classified under rukyat bil fi'li, which refers to direct, action-based observation grounded in actual visibility. Upholding this principle ensures that technological aids align with Islamic legal norms in determining the beginning of lunar months. Accordingly, image processing may be accepted as a legitimate observational tool, provided it is used appropriately and within the ethical and technical boundaries outlined.

References

- [1] "Hilal | Observatorium Bosscha." Accessed: Feb. 27, 2025. [Online]. Available: https://bosscha.itb.ac.id/id/penelitian/topik_penelitian/hilal/
- [2] "ASTROFOTOGRAFI: Adopsi dan Implementasinya dalam Rukyatulhilal di Indonesia - Dr. Ahmad Junaidi, M.H.I. - Google Buku." Accessed: Feb. 27, 2025. [Online]. Available: https://books.google.co.id/books?hl=id&lr=&id=mOVcEAAAQBAJ&oi=fnd&pg=PR30&dq=ahmad+junaidi+astrofotografi&ots=NEYH4uvUGL&sig=_5aPVIWF7LWYWDJm

9EPqmVI4j2E&redir_esc=y#v=onepage&q=ahmad%20junaidi%20astrofotografi&f=false

- [3] "Pengolahan Citra Digital: Teori dan Aplikasi Nyata." Accessed: Feb. 27, 2025. [Online]. Available:
https://scholar.google.com/citations?view_op=view_citation&hl=en&user=zSKUVnQAAAAJ&citation_for_view=zSKUVnQAAAAJ:4TOpqqG69KYC
- [4] R. A. Mustaqim, "Pandangan Ulama Terhadap Image Processing Pada Astrofotografi Di BMKG Untuk Rukyatul Hilal," *Al-Marshad J. Astron. Islam Dan Ilmu-Ilmu Berkaitan*, vol. 4, no. 1, 2018.
- [5] P. Mahasena *et al.*, "CCD observation of daylight crescent moon at Bosscha observatory," *J. Phys. Conf. Ser.*, vol. 1127, p. 012049, Jan. 2019, doi: 10.1088/1742-6596/1127/1/012049.
- [6] S. Muslifah, "SAKSI RUKYATUL HILAL DENGAN BANTUAN TEKNOLOGI (Analisis Penggunaan Teleskop CCD Imaging dan Olah Citra)".
- [7] S. Sakirman, "Respon Fikih terhadap Perkembangan Teknologi Rukyat," *Al-Manahij J. Kaji. Huk. Islam*, vol. 14, no. 1, pp. 69–86, 2020.
- [8] Y. F. Mangaras, B. Bambang Yuwono, and B. P. Dessyanto, "Dasar Pengolahan Citra Digital," 2022.
- [9] S. R. Sulistiyanti, F. Setyawan, and M. Komarudin, "Pengolahan Citra, Dasar dan Contoh Penerapannya," 2016.
- [10] U. S. Ardi, "Karakteristik Metode Image Processing Untuk Rukyatul Hilal Studi Kasus di Dome Astronomi CASA PPMI Assalam, Solo," 2019.
- [11] S. Madenda, *Pengolahan Citra Dasar Dan Video Digital*. Ciracas: Erlangga, 2015.
- [12] B. Jähne, *Digital image processing*. Springer Science & Business Media, 2005.
- [13] "Understanding Contrast in Photography | Skylum Blog." Accessed: Feb. 27, 2025. [Online]. Available: <https://skylum.com/blog/understanding-contrast-in-photography>
- [14] J. Felix, "Penggunaan Kontras Warna dalam Fotografi," *Humaniora*, vol. 1, no. 2, pp. 315–324, 2010.
- [15] M. Ahmad Junaidi, *Astrofotografi: Adopsi Dan Implementasinya Dalam Rukyatulhilal Di Indonesia*. Q Media, 2021.
- [16] U. S. Ardi, "Validitas Metode Image Processing DOME Astronomi CASA dalam Rukyatul Hilal," *Al-Mizan*, vol. 14, no. 1, pp. 135–161, 2018.