The Islamic science research network UHAMKA's moon crescent observation system

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Abstract. In Indonesia, most of the people are still doing the observation hilal to determine the beginning of the month of Hijrah. Among twelve months of Hijrah, the most crucial hilal observation is when determining the beginning of Ramadhan, Syawal and Zulhijah month. In that three months, there are some religious rituals; those are fasting in Ramadhan, Idul Fitri at the beginning of Syawal, Arafah fasting and Idul Adha in Zulhijah month. Hilal observation is astronomy observation that can be done by using some technologies; those are a digital camera, telescope, and mounting. The Islamic Science Research Network (ISRN) UHAMKA develops telescope system to hilal observation consist of William Optics Zenith Star 71ED telescope, CCD Celestron Skyris 274M camera, Baader infrared filter, mounting iOptron CEM60, and sharcap application to control camera which have loaded function of image capture, image correction, and image stacking.

1. Introduction

Since the time of Babylonia even before, the way to predict hilal visibility has been developed with a simple parameter. First, the age of the moon or the time difference between conjunction event with the time of the moon set. Second, the time difference between the sun and moon set [1]. Names like Ibn Tariq, Habash, Al-Khwarzmi, Al-Khazin, Al-Tabari, Al-Fahhad, Al-Kashani [2, 3, 4, 5] are figures who have been done development and observation about crescent moon visibility criteria. There are some results from the observation which have been done by a remarkable Muslim scientist, such as Zij table; the astronomical-mathematical tables, and observation instrument like astrolabs [6]. In the ancient time, before the telescope was created, the observation of sky objects still use eyes [3].

The simple parameter clearly is a parameter of sky objects visibility include crescent moon if use eyes. More systematic research about limit the ability of the eye to see sky objects have done by Danjon's, which later became known as the limits of the Danjon. Based on it, the crescent moon can be seen by eyes with the condition of distance between moon and sun (elongate) minimum 7.5°, while use telescope with the good condition of the sky minimum elongates 5° [1,3,7]. The sight of the first crescent by some Muslims used as an entry sign of the beginning of the month, and then most people use the limit of Danjon as criteria of the beginning of the Hijrah months. Therefore, the research about the limit visibility of crescent began to do by Muslims scientists which coincided with the research criteria of the beginning of Hijrah months. Beside Danjon, there is one more person like Muhammad Ilyas [4].

The use of telescope is very helpful in the process of hilal observation [8], with technology progress now available astronomy observation instruments like digital camera, automatic and computerize mounting, filter, application of camera control, application of modification and image processor that can be used to hilal observation [9,10]. Even with the progress of science and technology, today hilal observation not only can be done when sunset but also at noon [11].

The Islamic Science Research Network (ISRN) Prof. DR. HAMKA Muhammadiyah University has the duty and function of conducting research and development related to science and Islam, hilal observation. Islamic practical astronomy science is an important part of the study of ISRN UHAMKA which have developed some configurations of hilal observation system. In this paper, the writer presents the configuration of hilal observation system used and success gets the image of hilal in Karya Island, Kepulauan Seribu for the beginning of Syawal 1439H.

2. Instruments

2.1. Instrument for Observations

ISRN UHAMKA uses computerize instruments for mounting, application of camera control to image processor, and digital camera which its configuration suitable with the optical tube so that image formation on detector plat in a digital camera is representative, about 50% to 80% [9] all views on camera digital detector. In general, the instruments are shown in Table 1.

Table 1. List of hilal observation system instruments of ISRN UHAMKA.

No	Device	Function	Type
1	Telescope	As the light source collector of the observed object	William Optic Zenith Star 71ED
2	Filter	As a wavelength filter besides infrared entering the detector	Baader IR pass filter 685nm
3	Detector	Instrument capture signal or light source from the observed object	CCD Celestron Skyris Camera 274M
4	Mounting	As a holder placed a telescope that also serves as an automatic drive to follow the movement of the observed object, it is more commonly called mounting	Ioptron CEM60
5	Baffle	Used to filter the sunlight that goes into telescope lenses that disturb the contrast of hilal light	Self-made
6	Software interface and control camera	Used for the detector function has been doing data retrieval, storage, and image modification to increase hilal light	Sharpcap

2.2. Telescope.

ISRN UHAMKA uses William Optic Zenith Star 71 ED telescope, which has lens diameter 71 mm and ratio focus f/5.9. The detail characteristic of William Optic ZS71ED telescope is on Table 2 and Figure 1 and Figure 2.

Table 2. The characteristic of William Optic Zenith Star 71ED [12].

Character	Description
Lens opening	71mm
Centre ratio	F/5.9
Focus length	418mm
Lens type	ED Doublet, Air Spaced, Fully
Objective	Multi-Coated, SMC coating
Resulting power	1.58"
Magnitude limit	11
Lens cover	slideable
Focuser	50.8 mm (2") Rack &Pinion Focuser with 1:10 Dual Speed micro focuser 80mm (3.2") Focuser Travel Length 360 0 Rotatable Design
Tube diameter	93mm
Tube length	310mm
Seating type	Integrated L bracket
Mass	2.7 Kg

Figure 1. William Optic Zenith Star 71ED.

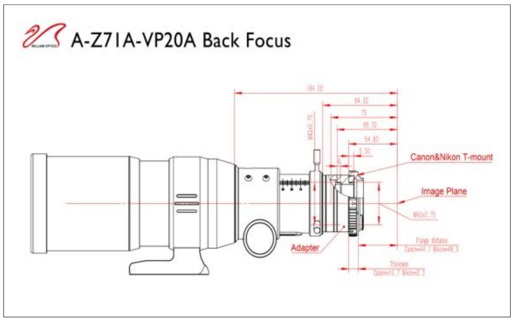

Figure 2. Detail characteristic of William Optic ZS71ED.

2.3. Filter

Hilal observation has a constraint that is the low contrast between the hilal with its foreground form of the atmosphere that scatter the sun's light with various wavelengths. To narrow the wavelength that goes into the telescope and detector, then a filter is used. ISRN UHAMKA uses infrared pass-filter, it means that all the wavelengths that enter the telescope and the detector are filtered, while the infrared wavelength is continued. ISRN UHAMKA uses infrared filter Baader IR pass-filter 685mm, as seen in Figure 3.

Figure 3. William Optic Zenith Star 71ED.

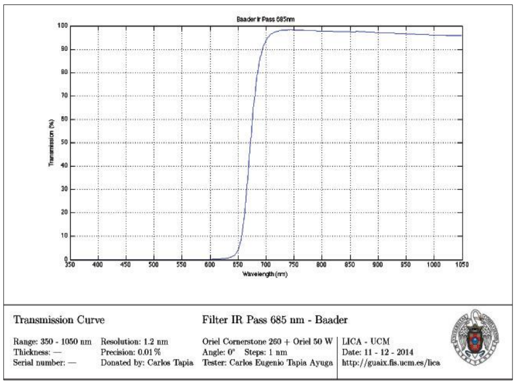

Figure 4. Detail characteristic of William Optic ZS71ED.

2.4. Detector.

The detector used must be customized to the characteristic of the telescope. The configuration between detector characteristic and telescope characteristic expected produce image of the observed object is proportional. If the shadow is too small or too large, then the observation will be very difficult to be done because it will produce bad data and image. Specifically for hilal observation, preferably the shadow of the moon occupies about 50% to 80% [9] from the detector field in order for the shadow to fall into the proportional detector for the treated processor and contrast enhancement. Considerate that configuration, because of ISRN UHAMKA uses William Optic ZS71ED, then it uses camera detector CCD Celestron 274M, as in figure 5. This camera is a monochrome camera that means each pixel's intensity stretches between 0 to 256 or known as grey scale, where 0 indicates black scale while 256 show white scale.

Figure 5. CCD Camera Celestron Skyris 274M.

2.5. Mounting

Besides for the place where the telescope was installed, mounting also for the automatic drive to follow the observed object movement. ISRN UHAMKA uses computerized mounting or there is a running computer system automatically move telescope follow the moon movement to the earth. There are some rules to be done by observer before doing the observation, such as (1) set position orientation in the earth, (2) time and date, and (3) choose the observed object. Mounting used by ISRN UHAMKA is iOptron CEM60, the mounting characteristic shown in Figure 6 and 7.

Figure 6. Mounting with telescope and baffle.

Figure 7. Mounting iOptron CEM60 only.

2.6. Baffle.
Observes hilal, especially to record-breaking contestation elongation, spawned a separate problem that is the strength of the sun's light because of its relatively close distance. To solve the problem, ISRN UHAMKA added an additional instrument that is a light filter (baffle) that will filter other light sources such as sunlight and light due to scattering. For light filtering, there are two types of filters used by ISRN UHAMKA, the first is a very simple form of black rolled paper as in figure 8. Second, self-made filter by considering the function and ergonomics, a light filter made as shown in figure 9. The function of light filter besides to filter the disturbed light sources, also to increase the contrast 13% [9].

Figure 8. Simple of Baffle.

Figure 9. Baffle with structure.

2.7. Software interface and camera control.
Different with hilal observation system of ISRN UHAMKA before [10], in this paper, the application used is Sharpcap which is developed by Robin Glover and David Richards [13]. SharpCap is an easy-to-use and powerful astronomy camera capture tool. It can be used with dedicated astronomy cameras, webcams, and USB frame grabbers. A wide range of features makes SharpCap suitable for many types of astro-imaging including Planetary, Lunar, Solar, Deep Sky and EAA (Electronically Assisted Astronomy). A clear and logical UI makes the program easy for beginners to use. Sharpcap used in this paper and in the observation on June 14, 2018 version 2.9.

There are two versions of Sharpcap, that are free and paid. The obvious difference between the free and paid version is for the free one, an image that has been corrected by dark and flat cannot be stored, while for the paid version it can be saved as well as the image with live stacking mode. In addition, Sharpcap supports for production cameras from Altair Astro cameras, Basler cameras, Celestron of Imaging Source cameras, iNova cameras, point grey or FLIR cameras, StarlightXpress cameras, ZWOptical cameras, and other brands that have an ASCOM driver [13]. Sharpcap view as in Figure 10.

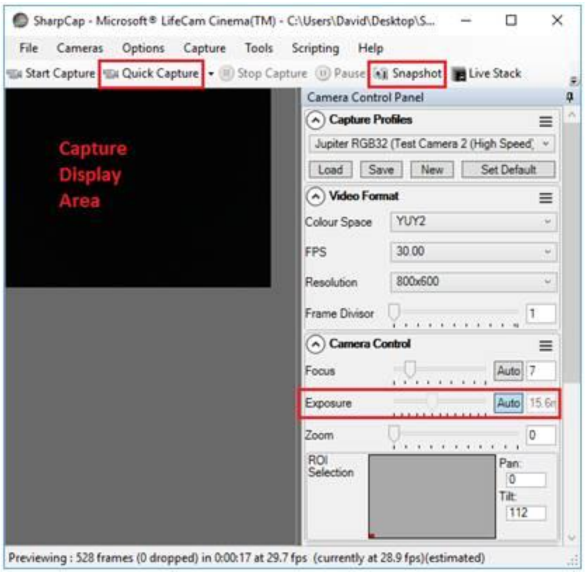

Figure 10. Display of Sharpcap.

3. Method

3.1. Observation step

By using iOptron CEM60 mounting which has been computerized, each targeted object by inputting the object name on the handset then mounting will lead automatically to the object and follow its motion, the process is called tracking object. However, prior to tracking, the mounting orientation of the observation location should be adjusted and do a process called alignment. When the followed object is matched with the existing database in the mounting, then the condition is appropriate between the database and the natural conditions. Actually for a good alignment process required at least 2 stars, then to do the alignment with the star then the assembly and telescope orientation and mounting arrangements did the night before the hilal observation. But for the process of hilal observation, the alignment process can also be done using the Sun.

After mounting orientation and telescope is suitable with the natural conditions, then the steps that must be done is to provide a synchronization command which means between the database and natural conditions have been appropriate. Observation of hilal using the camera control application and image processing allows image stacking and image correction simultaneously. Before doing image correction and image stacking, we need to take a correction image that is dark and flat [14].

3.2. Time and Place of the Observation

The observation was done on Thursday, June 14, 2018, in Karya Island (latitude -5.735319, longitude 106.598843), Kepulauan Seribu DKI Jakarta. The location of the observation is the beach, with the western horizon of the sea. Hilal observation is done in the context of ISRN UHAMKA's role in assisting the community in the hilal observation process, at this observation to assist the rukyat hilal team of Jakarta Islamic Center (JIC). Rukyat hilal team consisted of perukyat from JIC, perukyat from MUI DKI Jakarta, KANDEPAG Kepulauan Seribu, and judges of Religious Court of North Jakarta [15].

4. Result and Discussions

Observations were done by the team rukyat hilal JIC make observations with the naked eye but no one perukyat who managed to see, but with far elongation from Danjon limit. In contrast to the JIC rukyat team, the UHAMKA ISRN with its hilal observation telescope system obtains hilal image obtained at 18.07 (UT + 7) with elongation of 13.37º [16], month altitude 3.24º, and Moon illumination 0.7% [17]. The hilal image of the observation as shown in Figure 11 [18,19].

Figure 11. Moon Crescent in June 14 2018, 18.07 (UT+7)

5. Conclusion

The use of the telescope system is very helpful in the hilal observation to get the image of hilal. Hilal observation with the naked eye is very difficult even though the hilal condition exceeds the limit of Danjon. In the observation instrument setting, mounting orientation and telescope settings determine the success of the observation because it will direct the telescope to the targeted object.

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