

## The Utilization of Artificial Intelligence in Determining the Beginning of Islamic Calendar in Indonesia

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### Abstract

Recent technological advancement, artificial intelligence (AI), allows for the integration of human intelligence algorithms and application machines. As AI develops, it will be able to assist people in a variety of areas, including business, health, education, and others. The advantages of AI in establishing the start of the Hijri month are one of the benefits that we will discuss in this paper. Muslims, especially Indonesian Muslims, are now highly interested in learning about the Hijri calendar, especially as the months of Ramadan and Shawwal begin. Community organizations have repeatedly criticized the government's determination of the month's beginning in recent years with some argumentation provided. In order to address this issue, we will attempt to apply AI to pinpoint the start of Islamic Calendar especially in these months. This paper shows that in Fiqh and Astronomical Perspectives, Artificial Intelligence cannot be used as the main instrument in determining the beginning of the Islamic Calendar in Indonesia.

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### A. Introduction

Humans' approach to problem-solving in their daily lives has evolved thanks to artificial intelligence (AI). Artificial intelligence was created with people in mind, saving them time and effort. Human works will benefit from the best fixes and ideas from AI to make them even better. AI is capable of comprehending meaning, thinking, reasoning, and generalizing in order to draw lessons from the past. Even artificial intelligence can identify voices and signatures.[1] According to Hawking, artificial intelligence that is currently developing has negative and positive impacts because it has abilities that go beyond humans as its creators.[2]

Nowadays, the very rapid development of AI has also entered the realm of religion. There are several studies on AI and its impact on religious studies. Amana Raquib tries to position AI in a holistic Islamic policy based on maqashid. According to him, the ontological basis used by AI needs to be developed so that the wealth of Islamic scientific traditions cannot be separated from current socio-political and economic influences.[3] Furthermore,

research from Wardah Yuspin, which tries to see the use of AI in reducing the risk of profit sharing in Islamic banks. This study concludes that AI will have a major impact on the Islamic finance industry in Indonesia.[4] However, various efforts are still needed that will have a major impact on the Islamic finance industry in Indonesia. In addition, Ali included a representation of AI from Islamic philosophy in his paper. Ali concluded by saying that AI did not merit to be disregarded. AI must help solve issues in religious life while still respecting moral principles and human values.[5]

According to part of the study mentioned above, there hasn't been any writing that focuses explicitly on the use of this AI in Indonesia, where there are still numerous variances, to photograph and resolve issues with the Islamic calendar. This essay aims to address the flaws of earlier research that did not take into account Indonesia's particular challenges in determining the Islamic calendar. The investigation of fiqh and astronomy using AI in this context will be covered in great detail in this paper, along with how AI is utilized in Indonesia to determine the Islamic calendar. Understanding how AI is used to determine the Islamic calendar in Indonesia would aid the government in finding solutions to a number of issues related to doing so.

## **B. Method**

This paper collects data on the determination of the start of the month of Ramadan and Shawwal in Indonesia in Indonesia over the last 5 years. I use chat.openai.com for collecting data. After the data was collected, I compared it with the decisions that had been made by the Indonesian government, in this case the Ministry of Religion. Then we tried to see the differences between the two results and analyzed them from the perspective of Islamic Law and Astronomy. Apart from that, I also compared these results with several criteria that exist in Indonesia.

## **C. Results and Discussion**

### **Research Results**

#### **1) Islam and Science Integration on Islamic Calendar**

Nowadays, advances in science and technology will affect the development of Islamic law and changes in interpretation of *fiqh*. Of course the understanding of the scholars in responding to a problem will consider the aspect of benefit, as circumstances change, time and

culture in society. Included among them is the development of the method of determining the beginning of the Hijri calendar. Examining the interpretation of *al-Baqarah* 189, the Islamic scholars stated that in determining the beginning of the Hijri calendar, only by *rukyat* method.[6, p. 232] If the new moon was not visible then the month number was completed by 30 days.[7, pp. 266–267] This is also based on the hadith of the Prophet which states so. Therefore, it can be understood that in determining the beginning of the Hijri month, only by the *rukyatul hilāl* and *istikmal* methods are known.

Along with the development of the times, the understanding of determining the beginning of the Hijri month has also changed. Today, we have found that the implementation of *rukyat* is no longer conventional, but now we are using optical devices in the form of telescopes and equipped with several supporting instruments such as cameras. With the camera, currently the new moon can be imaged and even observed and recorded directly. In addition, astronomical calculations are more accurate than in fact. The description above influences the interpretation of the textual arguments, both the Qur'an and hadith. The word *rukyat* is not only interpreted in text, namely *rukyah bi al-fi'li*, but now it can be understood in *rukyah bi al-`ilmi* or by the method of calculation (*hisāb*).[8, p. 373] Therefore, now there are those who understand that *rukyat* can be replaced by *hisāb*. Although many also think that *hisāb* is a good guide in carrying out *rukyat*.

In this modern era, there are scholars who advocate the use of *hisāb* in determining the beginning of the Islamic month. Muhammad Rasyid Rida, based on his interpretation, *hisāb* is not only a guideline in carrying out *rukyat*, but also can be used as a determinant of the beginning of the Hijri month.[9, p. 635] Yusuf Qardhawi also conveyed the same thing, he explained why during the time of the prophets the *rukyatul hilāl* was used, because this was considered the easiest to do. In contrast, to today with the development of knowledge this can be replaced by *hisāb*. [10, pp. 60–63] Therefore, it can be concluded that the reason (*illat*) is legal already different.

The shifting paradigm in understanding of textual texts has occurred as a result of the times and technological developments. In fact, not only about the meaning of *rukyat* which is *bi al-fi'li* or *bi al-`ilmi*, but also from each of the *rukyat* and *hisāb* itself has developed. The implementation of *rukyat* now uses sophisticated instruments, namely robotic telescopes equipped with cameras, even now *hilāl* imaging can be easily obtained with AI technology. For *hisāb*, the data are more accurate because they are equipped with modern mathematical

formulas with various kinds of corrections, so that the results are almost the same as the reality. In the end, the development of science and technology can be utilized in understanding the arguments of the texts. But it doesn't mean that science is always right, so if according to science its wrong then the textual argument is wrong, it could be that our understanding of understanding the text's argument is not quite right.

## 2) Methods on Determining Islamic Calendar

There are 2 methods for determining the beginning of the month in the Hijri calendar, namely *hisāb* and *rukyat*. Both of these methods have their own characteristics in their determination. *Hisāb* is synonymous with a mathematical approach while *rukyat* is with an observational approach. *hisāb*, which in language means calculation,[11, p. 75] is the determination of the beginning of the month based on astronomical mathematical calculations to determine the position of the moon in determining the beginning of the month on the Hijri calendar.[12, p. 25] In its development, *hisāb* is divided into several types.

Firstly, *Hisāb 'Urfī* which is classified as the simplest calculation, the article is only based on the average calculation of the moon around the earth. Because it is only an average, this calculation is not appropriate when used as the basis for determining the time of worship.[13, p. 7] Even the age of the month has been determined, namely the odd month is 30 days old and the even month is 29 days, of course this negates the position of the moon/crescent at the time of the beginning of the month.

Secondly, *Hisāb Haqīqī*, namely calculating the actual circulation of the Sun and Moon.[13, p. 32] Calculations on the true calculation model can use astronomical tables, logarithms, interpolation to simple to complex extrapolations based on spherical trigonometry formulas.[14, p. 105] Thus the age of each month is irregular but based on the position of the new moon towards the beginning of the month. There are three types of *Hisāb Haqīqī*:

- a. *Hisāb Haqīqī bi al-Taqrībī*, namely determining the beginning of the month based on the calculation at the time of *ijtimā'* (conjunction).[15, p. 32] The characteristic of this model is that it uses old tables from Ulugh Beik while the calculation process is simple without using the spherical trigonometry formula. Some of the books that use this calculation include the book *Sulamun Nayyirain*, *Fathu Rauful Manan*, *Tadzkirotul Ikhwan*, and so on.[16, p. 101]
- b. *Hisāb Haqīqī bi al-Taḥqīqī*, determining the beginning of the month with this method has calculated the positions of the Sun and Moon and their nodes in ecliptic coordinates. While

the table used has been corrected with relatively complicated calculations and has used the spherical trigonometry formula. This model has taken into account the height of the new moon by taking into account the declination, the angle of the moon, and the latitude of the place, only the angle of the moon's orbit is considered static / does not change.[15, p. 29]

- c. Contemporary *Hisāb Haqīqī*, the characteristics of this model are that it uses the latest astronomical data and uses a more complex mathematical calculation model in determining the position of the moon and sun. Included in this method is Newcomb, EW. Brown, Jean Meeus, Almanac Nautika, Astronomical Almanac, Ephemeris Hisab Rukyat, Islamic Calendar, Mawaqit, Al Falakiyah, Moon C52, Asto Info, MABIMS, BMKG, and Boscha ITB.[17, p. 73]

The next method in determining the beginning of the Hijri month is *rukyyat* (observation). *Rukyyat* in determining the beginning of the Islamic month is to observe the new moon on the 29th day of the Hijri month. The real *hilāl* is the first phase of the moon after *ijtimā'* which is observed when the sun sets. This is what the prophet taught his people, although nowadays some people interpret the meaning of *rukyyat* as *rukyyat bi al-`ilmi (hisāb)*. *Rukyyat* activities are usually carried out in a place where the view to the western horizon is free of obstructions, such as a beach, hill or tall building. In carrying out the *rukyyat*, if an observer succeeds in seeing the new moon, then after the sunset a new date has been entered, but if the observer is not successful then the current month is completed 30 days, so that the first month falls on the day after tomorrow.[18]

*Rukyyat* in practice actually cannot stand alone, but needs calculation guidance. Thus, *hisāb* is a guide in doing *rukyyat* so that we don't get the wrong target when you observe the new moon. The positions of *hisāb* and *rukyyat* is complement each other in determining the beginning of the Hijri month. If *hisāb* is used as the only method, you will be faced with various types of calculation results and need field verification, as well as *rukyyat* will be wrong if it is not guided by accurate calculation.[19]

To sum up, the combination of *hisāb* and *rukyyat* rises to the concept of the crescent visibility criteria or *Imaknur Rukyah*. There are various criteria regarding this visibility, which in essence is to bring the results of calculation closer to the results of the *rukyyat* in the field. Determining the beginning of the month with the crescent visibility criteria is to bridge the two methods above, although at a practical level there is still a need for in-depth study of the existing criteria.

### 3) Determining Islamic Calendar in Indonesia

The Hijri calendar became known in Indonesia during the Islamic Mataram kingdom under Sultan Agung Hanyokrokusumo. At that time, the Sultan, who was known to be very religious, changed the Saka calendar system, which was guided by the movement of the sun, to become the Islamic Javanese calendar, which was guided by the movement of the moon. This idea was supported by the *'ulamā'* and courtiers and was considered as evidence of the extraordinary acculturation of Islam and Javanese culture. Apart from that, this creative idea can also be considered as the spirit of a Sultan in combining traditions and religious guidelines which become a bridge in the acculturation process.[20][21] The process of determining the beginning of the month in the Javanese Islamic Calendar or the Sultan Agung Calendar uses the *'urfī* calculating system.

The development of Islamic calendar studies in Indonesia then experienced developments along with the arrival of Indonesian students studying religion in Arabic. Islamic Astronomy is one of the sciences that is the focus of their study besides other religious sciences. One of those who proposed renewal in the Islamic calendar was Ahmad Dahlan. His anxiety is that the system for determining the beginning of the Hijri month in Indonesia begins when the month of Ramadan is set at 30 days, but according to the hadith, the month of Ramadan can be 29 or 30 days old. It was this anxiety that prompted Ahmad Dahlan to convey his ideas to Sultan Hamengkubuwono VII. According to him, the determination of holidays in the Islamic Javanese calendar is not in accordance with religious guidelines, so he offers to use *ḥisāb ḥaqīqī* in determining Islamic holidays. If according to reckoning it shows that the new moon will appear on the 29th of Ramadan, then the next day Muslims can already celebrate Eid al-Fitr. After listening to this explanation, Sultan Hamengkubuwono VII said that you should celebrate Eid according to *ḥisāb* and *rukyyat* methods, but the *Grebeg Suro* tradition will still be carried out according to Sultan Agung's calendar.[20]

After Indonesia gained independence in 1945, the determination of the beginning of the Hijri month was handed over to the Ministry of Religion which was formed on January 3, 1946 M/29 Muharram 1365 H. This determination relates to Islamic holidays throughout Indonesia. This decision regarding the duties of the Ministry of Religion was then reaffirmed through Presidential Decrees (Kepres) Number 25/1967, Number 148/1968 and Number 10/1971. The decision emphasized that the determination of Islamic holidays, including the determination of the beginning of Ramadan fasting, the beginning of the month of Shawwal,

and the beginning of the month of Zulhijah, was fully left to the Ministry of Religion.[11, p. 75] This decision means that in determining these dates, the Ministry of Religion has full authority and is a reference for Muslims throughout Indonesia.

In every decision regarding the establishment of a holiday, the government always holds an *isbat* session. Susiknan Azhari stated that the *isbat* session was a meeting held to determine the 1st of Ramadan, 1 of Shawwal, and 1 of Dhulhijah which was chaired directly by the Minister of Religion and attended by a number of Islamic organizations in Indonesia. The *isbat* session was first held in the 1950s by the Ministry of Religion as a first step to prevent unwanted things from happening, especially regarding differences in determining the beginning of the Hijri month. The *isbat* session was held on the basis of the fatwa of the clergy at that time and took into account the existing arguments. The *isbat* session assembly is conducted by the Government as an effort to facilitate and gather religious leaders from various circles to hold a deliberation in determining the beginning of the Hijri month. The Minister of Religion is only in charge of leading and announcing the agreement on the results of the *isbat* meeting without intervening in the substance of the session.

#### 4) AI on Islamic Calendar Determination

The utilization of AI in determining the beginning of the Hijri Calendar in Indonesia has not been much discussed by several researchers. I tried using chat.openai.com to retrieve data for determining the beginning of the month with AI. In this paper, I use the initial determination of the Hijri month for only two months, namely Ramadan and Shawwal for 5 years. The table below describes the search results for determining the start of the Hijri month using AI and compares it to the results of determining the start of the Hijri month by the government, The Ministry of Religious Affair of Republic Indonesia.

**Table 1.** Comparison between Indonesian Government and AI on Islamic Calendar

Month	Government Decision	AI	Gap
Ramadan 1440	May 6, 2019	May 6, 2019	-
Shawwal 1440	June 5, 2019	June 5, 2019	-
Ramadan 1441	April 24, 2020	April 24, 2020	-

Shawwal 1441	May 24, 2020	May 24, 2020	-
Ramadan 1442	April 13, 2021	April 13, 2021	-
Shawwal 1442	May 13, 2021	May 13, 2021	-
Ramadan 1443	April 3, 2022	April 3, 2022	1 Day
Shawwal 1443	May 2, 2022	May 2, 2022	-
Ramadan 1444	March 23, 2023	March 3, 2023	20 Days
Shawwal 1444	April 22, 2023	March 31, 2023	39 Days

Based on the table above, in 2019-2021, there is no difference in determining the start of the Hijri month between the determination of the beginning of the month using AI and the determination made by the government. Whereas, for the last 2 years, 2022-2023, there are several variations of different stipulations, namely at the beginning of Ramadan 1443 H, Ramadan 1444 H and Shawwal 1444 H. The month of Ramadan 1444 has a stipulation that is 20 days different from the government's stipulation. Whereas Shawwal 1444 H has a difference of 39 days from the government.

AI determines the beginning of the month includes a disclaimer that the determination of the beginning of the month in Indonesia still follows the existing authorities and depends on the observation of the new moon. AI also does not provide astronomical data which is a reference in observing the new moon and determining the beginning of the Hijri month in Indonesia.

## Discussion

### 1) AI on *Fiqh* Perspective to Determine Islamic Calendar

Alongside with changing times, technology is also developing so that it enters almost every aspect of life. *Rukyatul hilāl* in determining the beginning of the Islamic month also experienced extraordinary developments. Starting from simple non-optical equipment to optical and robotic-based equipment, namely telescopes and imaging software. AI is one of the technological developments that can be utilized in *hilāl* imaging.

The *rukyatul hilāl* activity is not just observing the new moon and then taking an oath, but the observed new moon can also be accounted for scientifically through the image of the new moon. That way the process of *rukyatul hilāl* activities does not only observe the new moon but also can be imaged scientifically. The sighting of the new moon is obligatory as a sign of the entry of the Islamic new moon, so intermediaries to get the sighting of the new moon are also mandatory. So that the process of *rukyatul hilāl* activities starting from observing to imaging can be said to be mandatory as well. In *fiqh* rules it is stated:

ما لا يتم الواجب إلا به فهو واجب

“A case that causes an obligation cannot be perfect except with that case, then the law of that case is also mandatory”[22, p. 46]

The existence of AI can be utilized to assist the *hilāl* imaging process so that the results of the *hilāl* image process using AI in the *rukyatul hilāl* activity can be witnessed by anyone. In the study of *fiqh* regarding additional instruments in the implementation of *rukyatul hilāl*, there are 2 (two) opinions of scholars, some say it is permissible and some say it is not permissible. In one hand, Ibn Hajar al-Haitami argues that the *rukyatul hilāl* does not use an instrument, such as a mirror. Actually, he did not expressly state that this was not permissible because there was no clear reason for his opinion.[23, p. 372] Abdul Hamid al-Syarwani explained that what Ibn Hajar meant was that it was more important not to use instruments, but using them was still permissible. The instrument is similar with lens that can magnify and bring objects closer, this is like the working principle of a telescope.[8, p. 372] In contrast, Muhammad Buhait al-Muti'i stated that the use of a telescope and the testimony of its visibility is permissible and valid, as the testimony on the naked eye because the essence is the same, what is seen through the telescope and the eye is the new moon itself.[24, pp. 293–294]

The AI used in the *rukyatul hilāl* activity is a technological development that can be used to make it easier to capture the *hilāl*. Previously, there had been Astrophotography techniques and AI can shorten the process of astrophotography itself. Both Astrophotography and AI are developed based on science, where science is explored from natural laws or *sunnatullah*. That way AI is an intermediary in knowing the new moon object, so its law is the same as the law of its purpose.[25, p. 39] In capturing the new moon through AI, there are 2 things that need to be considered, namely equipment and techniques. Of course, the telescope

and camera instrument equipment in observing the new moon must be installed, used, and directed correctly towards the new moon. Then the *hilāl* that is caught is easier to recognize through astrophotography techniques and/or with AI. So that the AI here is not holding something that doesn't exist, but clarifying the object being captured.

Islamic Jurisprudence is dynamic accept new developments and discoveries, including the *rukyatul hilāl*. Of course, the dynamism of *fiqh* does not mean that there are no limitations, but rather that it must be in accordance with the principles and objectives of the Shari'a and moreover bring benefit. The existence of AI in the *rukyatul hilāl* is a new invention that can be used to make it easier to capture the *hilāl*.

The appearance of the *hilāl* is one of the guidelines for beginning new moon with guidelines must be correct and convincing. In the mechanism of receiving the testimony of *rukyatul hilāl*, the Prophet swore by those who saw the *hilāl*. It indicates that the Prophet wanted a truly objective and convincing testimony. If we take it to the present day with technological developments, to measure the objectivity of the sighting of the new moon is not enough with mere testimony, but other evidence needs to be included in the form of *hilāl* images. The Islamic Scholars require a very strict *rukyatul hilāl* testimony. It indicates a big attention in receiving *rukyatul hilāl* reports. The appearance of the *hilāl* must be objective, not subjective. In its development, there are fundamental differences between the results of traditional *rukyatul hilāl* and modern *rukyatul hilāl*. Traditional *rukyatul hilāl*, the *hilāl* is seen by the naked eye of the observer and stored in the memory of the observer's brain, so it tends to subjectivity. Unlike the modern *rukyatul hilāl*, the *hilāl* is visible to observers and stored in computer memory and can be captured so that it can be seen by everyone and can even be verified using various methods.[26, p. 287]

In the perspective of Islamic Law rules, it is stated:

لا عبرة بالظن البين خطؤه

“Something that has subjective value and is clearly wrong will be ignored”[27, p. 357]

With the above *fiqh* rules it is clear that something objective is preferred over subjective. In the case of *rukyatul hilāl*, the results of *hilāl* image using both astrophotography techniques and from AI are evidence to add value to objectivity. In terms of testimony, the status of evidence will be the same as oral testimony. This is in line with the principles of *fiqh*:

الكتاب كالخطاب

“The status of the writing is the same as the status of the conversation/message”[27, p. 349]

### الثابت بالبرهان كالثابت بالعيان

“Something established by evidence is like something established by testimony” [27, p. 367]

Thus, with the image of the *hilāl*, it can be used as evidence and is judged the same as the testimony of people who saw the crescent. It should be emphasized that the *hilāl* image is really exists and not made up. The image processing using AI only clarifies the existing image. In other words, the imaging process with AI is a complement between the *hilāl* object and the observer.

## 2) AI on Astronomical Perspective to Islamic Calendar

Based on data above, it is known that the initial determination of the month by AI has not been able to show the main data in the process of determining the beginning of the Hijri month; namely astronomical data. I suspect that AI is not able to show this data because the astronomical data for determining the beginning of the Hijri month are not all provided in search engines so that these data cannot be found. In addition, astronomical data is also based on location and each authority in several locations does not always update data every month. Astronomical data must be provided based on data requests, cannot be operated automatically so that the algorithm provided by AI has not reached this capability.

This paper also compares with the determination set by the government. Based on data above, the results of the determination of AI tend to be the same as the government within 3 years after the determination. Meanwhile, in the last 2 years, AI has tended to have an anomaly in the government's determination of the beginning of the month. The difference in this time period at least shows a number of things. Firstly, a lot of astronomical data in the 3 years before the search had been uploaded by local authorities so that AI could easily access these data. Contrary to this data, the data for the last 2 years has had a lot of dynamics and has not been uploaded by the authorities. This has implications for the many oddities of the data displayed and there are even differences of up to 39 days. This phenomenon clearly shows a very big weakness of AI because usually the difference in the initial determination of the Hijri month ranges from 1 to 2 days. The difference of up to 40 days also shows that AI has not been able to provide detailed data as needed in the process of determining the beginning of the Hijri month.

The phenomenon of determining the beginning of the Hijri month with AI has a variety of correlations with the criteria used by the government and Muhammadiyah criteria. When

compared with some of the existing criteria, there is a tendency for AI to conform more with government criteria (MABIMS and Neo MABIIMS Criteria) than Muhammadiyah's wujudul hilāl criteria. AI is only in accordance with the wujudul hilāl criteria in 1 month's initial determination, in Ramadan 2022. With reference to astronomical data for that month and the use of the new MABIMS criteria, I think that AI still refers to the old-MABIMS criteria where these criteria have some with the new-MABIMS criteria.

#### **D. Conclusion**

This paper shows that in Islamic Law perspective, AI cannot be used as the main instrument in determining the beginning of the Hijri month. AI is only used as a complementary instrument in processing new moon images. While the testimony of the new moon must be conveyed by a surveyor, not by a machine. Meanwhile, astronomically, AI also cannot be used because AI has not been able to provide detailed calculation data and it is still very likely that there will be differences from the initial determination of the month in general. The correlation of AI with the criteria for the visibility of the new moon cannot be shown clearly, especially from real-time data.

This research is expected to be able to complement previous studies in discussing the determination of the Islamic Calendar in Indonesia. This paper only accommodates limited samples, limited cases, and short time references. Due to these limitations, it is suggested that a further study is needed that accommodates a larger sample, a wider locus so that it can establish trends in the suitability of AI with existing visibility criteria.

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