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Application of Artificial Intelligence in Automatic Crescent Moon Detection System Using Teachable Machine Model on Web Platform

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Abstract

The issue of the visibility of the new moon (hilal) often becomes a recurring debate, especially during two major Islamic occasions: the determination of the beginning of Ramadan and the start of Dhu al-Hijjah for Eid al-Adha. In the practice of rukyat (moon sighting), claims of hilal sightings are frequently made without strong or objective evidence. Therefore, the utilization of artificial intelligence technology, particularly in the field of image classification, presents a potential solution to improve the accuracy and objectivity of the moon sighting process. This research employs an image classification model trained using the Teachable Machine platform. The trained model is then integrated into a websitesite developed using HTML, CSS, and Python, and hosted via the github service. Through this websitesite, rukyat observers can upload photos of the sky captured during moon observation. The AI model will then analyze the uploaded image to determine whether the hilal is visible or not. This system is expected to serve as a scientific and modern tool to support the moon sighting process.

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A. Introduction

The Hijri calendar is a calendar system used by Muslims in determining the times of worship such as fasting Ramadan, Eid al-Fitr, and Eid al-Adha. The determination of the beginning of the month in the Hijri calendar is highly dependent on the observation of the new moon, which is the first appearance of the crescent moon after sunset at the end of the current month. The most crucial moment in this practice occurs at the beginning of the months of Ramadan, Shawwal and Dzulhijjah. The decision on when Muslims start fasting, celebrate Eid al-Fitr and carry out Eid al-Adha depends heavily on whether or not there is a moon visible in the western sky [1]. Therefore, accuracy in determining the existence of the hilal is very important, not only in the religious aspect, but also in maintaining uniformity in worship times in various regions.

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In practice, the rukyat method or direct observation of the hilal often causes differences of opinion between groups or regions. It is not uncommon to find one-sided claims about the appearance of the hilal that are not supported by strong and verifiable visual evidence. This causes a discrepancy between the time of worship in one region and another, even in one country [2]. In addition, direct observation of the new moon requires skills, favorable weather conditions, and optical aids such as telescopes or special cameras. These challenges further demonstrate the importance of applying modern scientific and technological approaches in supporting the rukyat process.

As technology develops, the use of artificial intelligence (Artificial Intelligence or AI) has made a significant impact in various fields, including in the fields of astronomy and image analysis. One of the branches of AI that has a big role in visual analysis is Image Classification or image classification. This technology allows computers to identify and classify objects in images based on certain patterns that have been studied before [3]. Using this approach, the system can help analyze whether the moon is visible in a photo or not, so that the verification process can be carried out more objectively and accurately.

In this study, the author developed an artificial intelligence-based automatic hilal detection system that utilizes an image classification model from the Teachable Machine platform. The platform enables the training of AI models in an easier and faster way using manually provided image datasets. The trained model is then integrated into an interactive website built using the HTML, CSS, and Python programming languages, and hosted on the Replit platform for online user access. Through this website, users (perukyat) only need to upload photos of sky observations, then the system will process and analyze the photos to determine the possible existence of the new moon.

This system is designed to be a practical and scientific tool in the rukyat process. In addition to providing quick analysis results, this system is also able to provide visual clarity about the classification process carried out. It is hoped that this technology can contribute to improving the accuracy of moon observation and reduce differences in determining the beginning of the Hijri month in the future. By combining traditional rukyat methods and modern technology, it is hoped that a more harmonious approach will be created and acceptable to various parties.

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B. Method

This research uses a system engineering approach with a prototype development method. The stage begins with the collection of sky image datasets which are divided into two categories, namely images with the new moon and without the moon image. This dataset is then used to train the image classification model using *the Teachable Machine* platform. Once the training process is complete, the model is exported in a compatible format and integrated into the website. The website is developed using the Python programming language with the Flask framework as the main backend, as well as HTML and CSS for the interface. AI models are integrated into the system in order to analyze the images uploaded by users. Then the website is hosted using github for easy online access. The test was carried out to evaluate the accuracy of the model in detecting the new moon and ensure that the functionality of the website runs properly.

C. Results and Discussion

Hilal as One of the Indicators of the Beginning of the Month

Hilal is one of the important markers in the Hijri calendar system used by Muslims around the world. Hilal is the first crescent moon seen after the ijtimak (conjunction) between the moon and the sun. The appearance of the new moon determines the beginning of the new month in the Islamic calendar, such as Ramadan, Shawwal, and Dzulhijjah, so that it greatly affects the implementation of worship and the determination of religious holidays [4]. In practice, the determination of the beginning of the month is carried out by two main approaches, namely hisab (astronomical calculations) and rukyat (direct observation of the new moon). These two approaches often cause differences, especially when the results of the hisab state that the hilal is possible to be seen but when the observation or rukyah of the hilal does not succeed in detecting it, which can occur due to weather factors or the lack of light of the hilal [5].

To overcome these differences, the MABIMS country forum (Minister of Religious Affairs of Brunei Darussalam, Indonesia, Malaysia and Singapore) has agreed to use the imkan rukyat criteria as a reference standard in determining the beginning of the Hijri month. MABIMS' criteria updated in 2021 state that the moon is declared possible if it meets two conditions, namely the height of the moon at least 3 degrees and the angular distance (elongation) between the moon and the sun at least 6.4 degrees at sunset [6].

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This criterion is designed to bridge the scientific approach of hisab and rukyat, so that the determination of the beginning of the month is more objective and uniform. However, the problem between hisab and rukyat still continues to occur today. Some groups still rely on rukyat as the only valid method in determining the beginning of the Hijri month, while others believe more in modern hisab [7]. Technical factors such as weather, location or geography, as well as the readiness of observation aids also affect the final outcome of the determination of the beginning of the month. In this context, technological developments such as the use of digital telescopes, CCD cameras, and even artificial intelligence (AI) are expected to be solutions to improve the accuracy of moon observations and reduce the differences that occur in society towards moon testimony [8].

One of the main problems that often arise in determining the beginning of the Hijri month is the existence of reports of rukyat (observers) of the hilal by certain parties who claim to have seen the hilal directly, but with very minimal or weak evidence. In some cases, the report is based solely on oral and sworn testimony, without being supported by valid visual documentation such as telescopic imagery, video recordings, or objective astronomical data. The reliance on personal oaths as the main evidence of the appearance of the new moon has a very high risk, because it can open a gap for misperceptions or even misidentifications of celestial objects. Newly emerging molasses are usually very thin and dim, making them very easy to mistake for other objects such as thin clouds, light pollution, or light spots from airplanes[9].

In addition, psychological factors also play a big role in the rukyat process. A person's tendency to want to be a witness to the first sighting of the new moon can affect his perception, especially when he is under certain social or religious pressures. This phenomenon is referred to as *wishful seeing* or vision that is influenced by personal desires, which can cause a person to feel confident that they have seen the new moon when it is not actually the new moon [10]. This is very prone to occur when atmospheric conditions are less supportive, such as fog, high humidity, or other optical disturbances, here is one photo that is prone to being misinterpreted whether there is really an image of the new moon or not.

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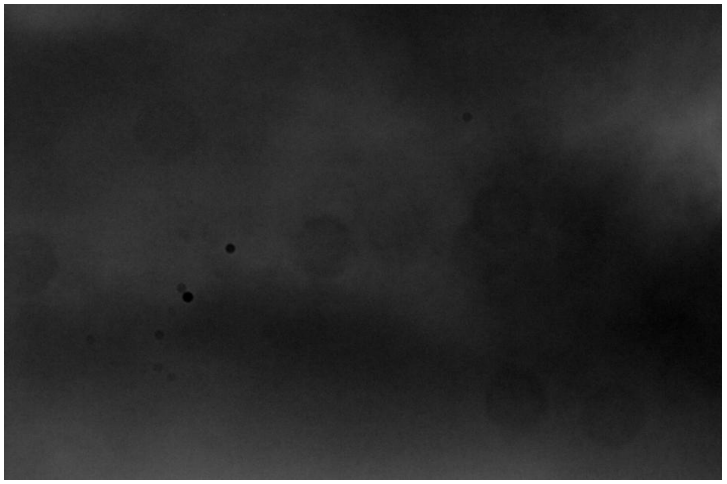

Figure 1. Examples of risky photos misinterpreted as there is a hilal

Utilization of Artificial Intelligence

Artificial Intelligence (AI) or artificial intelligence is a branch of computer science that focuses on creating systems or machines that are capable of performing tasks that generally require human intelligence. These tasks include the ability to learn from data, recognize patterns, make decisions, understand natural language, and perform classifications and predictions. In the context of modern technological developments, AI has developed rapidly and has begun to be implemented in various fields, such as health, transportation, manufacturing industry, to astronomy and religion [11]. The use of AI enables process automation that previously could only be done by humans, thereby improving efficiency, accuracy, and consistency of results.

One of the applications of AI that is relevant to the field of astronomy is in the process of moon detection, which is an important activity used to determine the beginning of the month in the Hijri calendar. So far, the process of rukyah hilal still depends on direct observation made by humans. This approach has various weaknesses, such as the limitations of the observer's visual ability, weather conditions, and subjectivity in interpreting the visible image of the hilal. In an effort to improve the objectivity and accuracy of the hilal detection process, artificial intelligence is present as a potential alternative solution.

Through a machine learning approach (*Machine Learning*), AI can be trained to recognize the shape of the moon from the sky image dataset. One of the platforms used in this study is *Teachable Machine*, a website-based tool developed by Google that allows users to create AI-based classification models without requiring complex programming knowledge. The platform allows users to train models with datasets of hilal images and non-hilal images,

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so that the model can automatically distinguish whether an image contains a hilal or not [12]. The trained model can then be integrated into a website-based system capable of classifying images in real-time.

The use of AI in automated hilal detection systems offers a new, more adaptive and data-driven approach in the early identification process of the Hijri month. Through image-based classification model training, AI is able to recognize the visual patterns of the moon with a high level of accuracy, even in minimal lighting conditions or certain visual disturbances. This approach allows the detection process to be carried out more efficiently and with minimal bias, because the system works based on parameters that have been processed computationally, not human perception. Another advantage is the ability of AI to be widely used in a variety of locations with different geographical conditions, as long as relevant sky imagery is available. Thus, the implementation of AI not only accelerates the detection process, but also contributes to strengthening scientific methodologies in the rukyah hilal, by providing a system that can be run consistently, measurably, and can be reverified.

Stages of Artificial Intelligence Model Development for Hilal Detection

The development of artificial intelligence models to detect the hilal is a systematic and structured process that involves several important stages, ranging from data collection to model performance evaluation. In the context of this research, model development was carried out with the aim of producing a classification system for hilal images that is accurate, efficient, and can be implemented in real-time through a website platform. Each stage is designed to ensure that the model is able to recognize the visual pattern of the new moon accurately based on the training data that has been prepared.

By utilizing *the Teachable Machine* as a development tool, this process becomes more affordable and accessible to researchers who do not have a strong programming background. Therefore, understanding the stages of model development is crucial to ensure the success of a reliable and applicative AI-based moon detection system.

Here's the process of building the model:

1. Collection of hilal image data

Collection of hilal image data is a very crucial initial stage in the process of developing artificial intelligence models. At this stage, various images of the new moon are collected from various sources, both from the results of direct observation documentation and from credible

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online references. After the data is collected, a selection and sorting process is carried out to determine which images meet certain quality criteria, such as image sharpness, clarity of the shape of the moon, and adequate lighting [13]. Only data that meets these criteria will be used as a dataset to train the model, with the aim that the machine learning process can take place optimally and produce a high level of accuracy in classification. In addition, this sorting also helps minimize noise or visual disturbances that can affect the model's performance in accurately detecting the new moon.

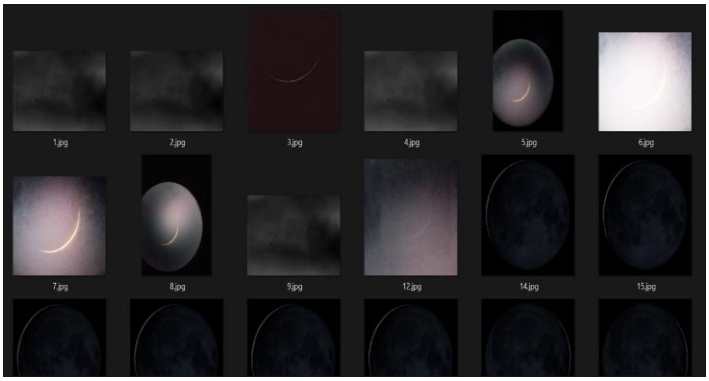

Figure 2. Hilal Image Data

After the collection of hilal imagery data has been successfully collected and selected based on its quality and feasibility for use in model training as shown in figure number 2, the next step is to collect non-hilal data [14]. Non-hilal data as shown in figure number 3 consists of sky images that do not show any appearance of hilal at all. The collection of non-hilal data is important to provide a comparison in the classification process, so that the artificial intelligence model can learn to accurately distinguish between images that contain hilal and those that do not. With the existence of two types of clear and structured data, namely hilal and non-hilal images, it is hoped that the model training process can be carried out more effectively and produce more accurate classification.

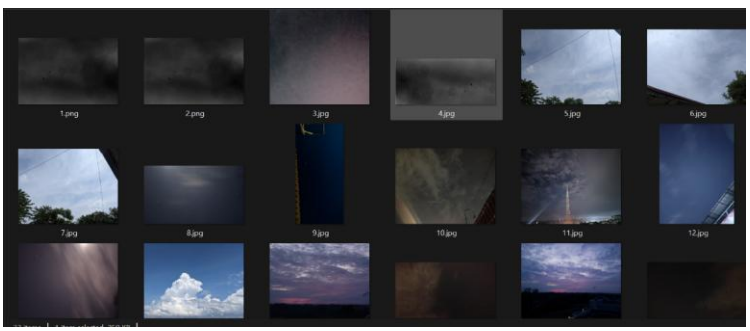

Figure 3. Non-Hilal Image Data

2. Training models with pre-prepared data

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After the data has been successfully collected and sorted to ensure that only images that meet the quality criteria are used, the next stage is to train the artificial intelligence model to be able to distinguish between images that contain the hilal and the images that do not have the hilal. This training process is carried out using the platform *Teachable Machine*, where the prepared dataset is put into two main categories, namely "hilal" and "non-hilal" [15]. Through this learning process, the model will learn the typical visual patterns contained in the hilal image, so that it can be classified automatically with optimal accuracy when run in a website-based hilal detection system.

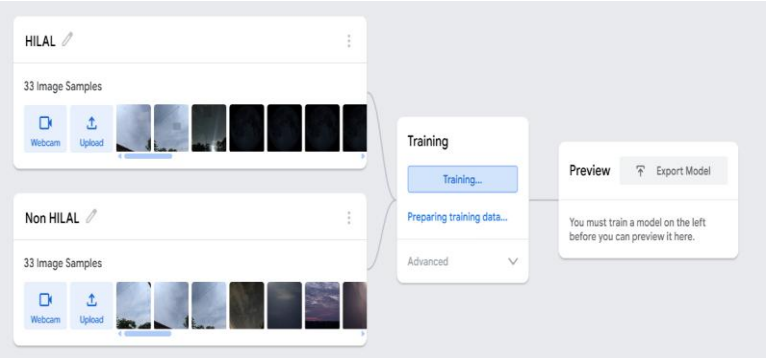

Figure 4. Data Training Process

In figure number 4, it can be seen that the data training process is carried out using *the Teachable Machine platform*. At this stage, the model is trained to recognize the difference between images that contain the hilal and the images that do not contain the hilal. The model learns gradually from the data that has been prepared and classified beforehand, so that it is able to identify the distinctive visual patterns that distinguish the two categories.

Once the artificial intelligence model has been successfully obtained through the training process, the next step is to integrate the model into a website-based platform. This process involves packaging the model into a website interface built using a combination of HTML and CSS programming languages for the display of the user interface (frontend), as well as Python to set the processing logic and integration of the model (backend). With this approach, users can access and use the hilal detection system interactively and in real-time through a browser without the need for additional installation.

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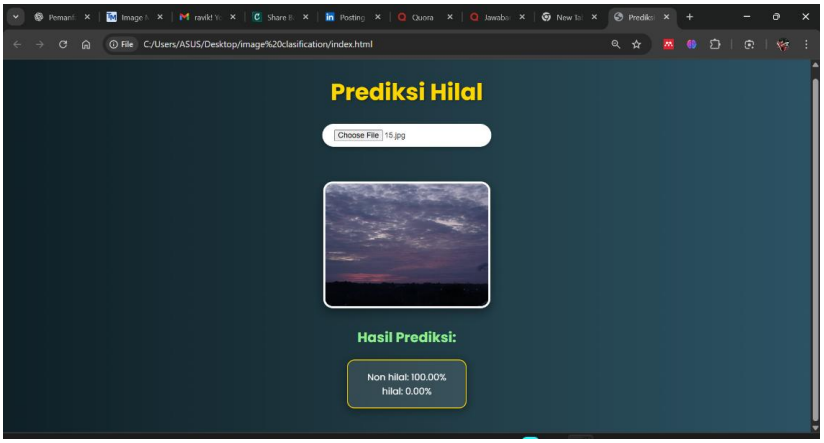

Figure 5. Hilal Analysis Website

After the artificial intelligence model has been successfully developed and packaged into a website-based platform as seen in figure number 5, the next stage is to host the application on the GitHub Pages service so that it can be accessed online by users or interested parties. Hosting through GitHub Pages allows the system to be widely accessed without the need for additional software installation, simply using a browser and an internet connection.

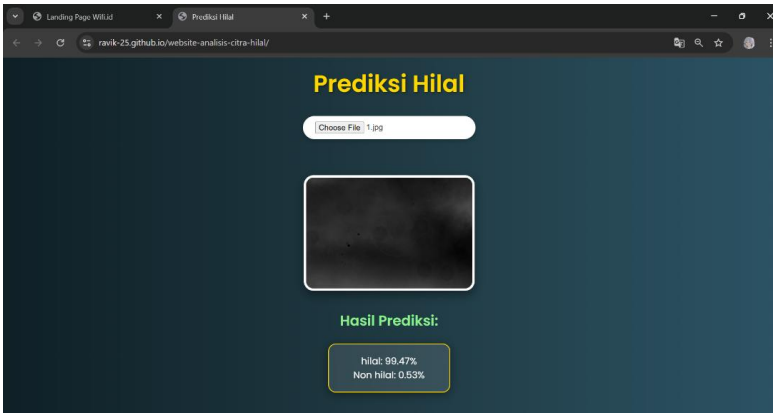

Figure 6. The results of the analysis of the appearance of the image of Hilal

In its implementation, users only need to upload the observed sky image into the system interface, and the model will automatically classify whether the image contains the hilal or not. With ease of access and a simple interface, this system is expected to be a practical and efficient tool in the rukyatul hilal process, especially in areas with minimal resources or experts. In addition, through a data-driven approach and automated visual analysis, this system can minimize the possibility of errors in identifying the new moon, such as thinking the new moon is visible when in fact it is not. This kind of error is often influenced by the observer's subjective factors, atmospheric conditions, or optical illusions in the twilight sky. Therefore, the existence of this system is expected to increase accuracy and objectivity in

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the process of determining the beginning of the Hijri month in a more scientific and standardized manner.

D. Conclusion

Based on the overall discussion, it can be concluded that the application of artificial intelligence technology, especially through the Teachable Machine-based image classification model, offers an innovative and effective solution in supporting the rukyat hilal process. This system is able to identify the existence of the moon automatically, objectively, and free from the influence of human subjectivity. By utilizing a structured dataset of hilal and non-hilal images, as well as a systematic model training process, this system is integrated into an interactive website platform that can be accessed online through the following link https://ravik-25.github.io/website-analisis-citra-hilal/ . This makes this A.I-based website a practical, scientific, and easy-to-use tool for anyone connected to the internet. The existence of this system not only helps to minimize the potential for errors in the identification of the hilal, but also contributes to the creation of uniformity in the determination of the beginning of the Hijri month between regions. Thus, the combination of traditional rukyat methods with modern AI-based technology can strengthen the validity of determining the beginning of the month in a more scientific, accountable, and inclusive manner, in accordance with the needs of Muslims in today's digital era.

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