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Egg Characteristic Identification System Using Thermal Imaging Camera Based on Image Processing

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***Abstract*— Fertility level is one of the main factors for the success of eggs in order to hatch properly. Detection of egg fertility is currently still based on visuals, namely by observing the eggs one by one. This takes time and money so that it will affect the results of poultry farming. This study aims to determine the distinguishing characteristics of fertile and fertile eggs using thermal imagery and region of interest methods. Sample images were obtained using a thermal camera. The image processing process is cropping and grayscaling. The main basis in this research is color. The color of the thermal image will be translated into a temperature that will determine the characteristics of the egg. Based on the research that has been observed, the characteristics of egg temperature are divided into two, namely the temperature of fertile eggs increases steadily, while in infertile eggs the temperature value is unstable every day and when approaching hatching, the temperature of fertile eggs will be higher than infertile eggs.**

Keywords—identiification, eggs, fertile, infertile, temperature.

I. INTRODUCTION

Eggs are shelled objects containing embryos produced by poultry (chickens, ducks, birds, etc.) [1]. Eggs as a result of poultry farming are one of the perfect foodstuffs because they have sufficient nutrients. Content such as protein, fat, vitamins, and minerals are needed for human survival. Besides having high nutritional value, the price is relatively cheap compared to other sources of animal protein.

Egg consumption continues to increase, this can be seen from the increase in egg consumption per capita and egg production in general in Indonesia. According to data from the Central Statistics Agency, egg consumption per capita per year was 18.44 Kg in 2017 and increased to 28.16 Kg in 2020 [2]. The incubation industry is one of the main industries in the production chain of poultry farming and plays a major role in poultry rearing. Egg hatchability is an important factor in the incubation industry. However, the most important factor is to make sure that the eggs placed in the incubator are fertile. Detection of infertile and non-hatching eggs will increase productivity and be profitable, as it saves space and costs, and prevents bacterial contamination of the eggs.

The success rate of hatching eggs can be increased by selecting and separating between embryonated eggs *(fertile)* and eggs that are not embryonic *(infertile)*. *Fertile* eggs are placed in an incubator for the hatching process. Meanwhile, eggs that do not have embryos can be immediately separated for consumption purposes. In general, to find out *fertile* and *infertile eggs, a candling* process is carried out. The *candling process* is labor intensive and is not very efficient. Fatigue factors and poor eyesight of the workers are the main problems because they have to check hundreds or even thousands of eggs per day. Therefore, only a few eggs are selected randomly based on the physical shape, color, and condition of the egg shells. This parameter is used to determine egg fertility, which means that most infertile eggs are likely to remain in the incubator. Apart from human resource and capacity issues, the remaining infertile eggs in the incubator may have been contaminated with bacteria, and as a result, the eggs rot and release certain gases into the environment which makes the situation problematic for the embryonated eggs.

Thermal imaging is a technique using infrared energy that is invisible to the human eye, the heat energy emitted by an object is then converted into a visual image. The image obtained using a thermal camera is an image that represents heat on a particular object. Because basically, every object that is above 0℃ temperature emits heat energy in the form of infrared waves [3]. IR rays are in the spectral region with a wavelength of 0.8 ~ 14μm [4].

Image acquisition is the initial process or the initial stage to obtaining the desired image or image. The purpose of image acquisition is to obtain the required data and choose a digital image recording method. Images that can be processed by computer devices are called digital images [5].Region of Interest (ROI) is a sample in a data set identified for a specific purpose [6]. ROI processing is used to process one subregion of an image, leaving the other regions unchanged. Image subregions can be easily defined using Mathematica Graphics primitives, such as Points, Lines, Circles, Polygons, or simply as a list of point positions. Regions can be geographic, such as

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polygons spanning adjacent pixels, or they can be defined by varying intensities. In the latter case, the pixels are not always contiguous [7].

Based on this description, an identification system to determine the characteristics of fertile and infertile eggs based on thermal images will be made. This characteristic identification system was created to keep up with the rapidly growing development of technology and information. So that it can help create equipment that can help the egg observation process automatically. In this study, a thermal camera will be used as a medium for taking internal images of eggs before being processed in digital image processing.

II. RELATED WORKS

In this time, thermal imaging has been widely used in the health sector, agriculture, energy generation, climatology, and geophysics. Thermal imaging is a detection method that improves the visibility of an object by detecting infrared radiation from the object and creating an image. The way thermal cameras work is that all objects emit infrared energy as temperature. Infrared energy emitted by an object is known as heat-imaging. [8].

Study using thermal imagery has been conducted by [3] which aims to build a camera system that can play an active role in the process of sorting eggs based on shape and size. The image obtained from the thermal camera is processed using software with morphological methods to separate the identification object from its background. The results of image processing obtained object recognition from single egg images and group eggs images. Each processed egg has a bounding box and a centroid that shows the size of the egg.

In this study [9] a thermal imaging system is presented for the identification and filtering of fertilized eggs. The system can detect the temperature of the target from the infrared image. The Sobel operator was employed to seek the outline of the eggs. Fuzzy theory is used to obtain the best threshold value for damaged eggs with the use of the grayscale co-occurrence matrix. Then the system can make a judgment as to whether each egg is good or bad. The accuracy of the system can reach 96%, and the detection speed is 2–3 sec. The system is easy to operate; even people without experience can use this system to identify bad eggs. With the use of machine vision in the testing process instead of personal judgments, timesaving can be achieved, and the quality can also be improved in the chicken farm operation.

Prediction of egg fertility has been studied [10] by analyzing color characteristics and egg index values. The candling image is used to determine the dimensions of the egg yolk. The classification results in this study were carried out with several algorithms to minimize the failure rate of determining fertile eggs. From the processing results in this study, the dimensions of 3 types of egg yolks were obtained which were considered the value of fertile eggs. In the round variant, it has a thickness of 56-59 mm and a diameter of 28 mm, round slightly elongated by 56-59 mm and 30 mm, and for egg yolks with an oval shape it has dimensions of 54-57 mm thick and 26 mm in diameter.

In this paper, we adopt the previous research mentioned above and propose the detection of egg fertility characteristics based on temperature obtained from thermal images to increase egg hatchability in the incubation industry which is one of the main industries in the production chain of poultry farming.

III. MATERIALS AND METHODS

In research on analyzing the temperature characteristics of fertile eggs using a thermal camera, the tools and materials used include the following: *FLIR C3-X Series* thermal camera, egg incubator machine, laptop, chicken eggs, and MATLAB software.

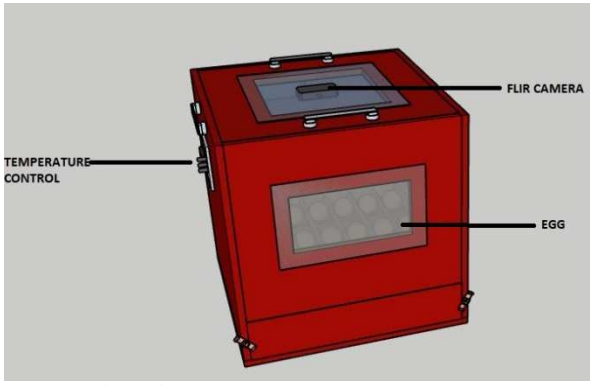


Fig 1. Incubator design

Overall, the stages in this research have three stages, namely, system component design, system design, and system performance and accuracy testing.

A. *System Components Planning*

The system components which have been designed consist of a camera, an incubator, and a thermometer.

B. *System Design Planning*

In this process, hardware and software design is carried out as well as performance testing of these two things so that the appropriate system is obtained. Design of the Display of Identification Results In this process, schematic design is carried out, integrating the display with the system, and performing performance testing. The system identification results will be displayed using the LCD on the camera. In stage 2, the results will be obtained including the design of hardware and software that is integrated with the system and displays the results of system identification using the LCD.

C. *Overall System Performance and Accuracy Testing*

This process is the final process in system design, performance testing includes accuracy and stability. The main field testing is done by using the product design results in real conditions. The test design is the same as the initial field test using the experimental method. If the results of the main field testing do not meet the expected specifications, it is necessary to revise the product. The results of the next revision are

used for the operational field. Operational field testing is carried out by testing the control system, including the identification and characterization stages. This stage is expected to obtain resolution data from the control system and its sensibility.

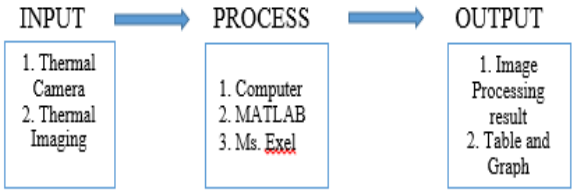


Fig 2. System Process

IV. RESULT AND DISCUSSION

A. Result

In this study, there are temperature samples that have been obtained from image capture using a thermal camera. Sample data or images are taken when the incubator lamp is off with a temperature of 38°C. After all the image-taking processes are carried out, all samples will be collected. Data is needed to determine the temperature characteristics of fertile and infertile chicken eggs. All data will be collected and presented through a table and graph which will be the basis for observation and analysis in this study. The following are 2 image sample data representing 16 image sample data obtained.

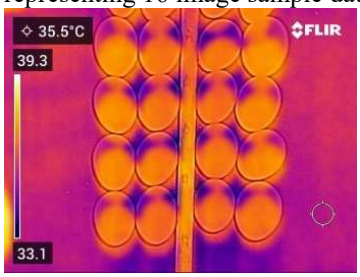


Fig 3. 4th day image

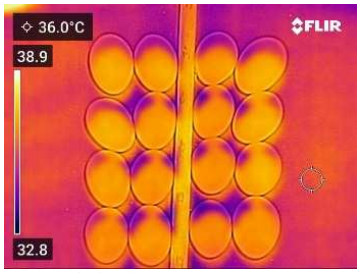


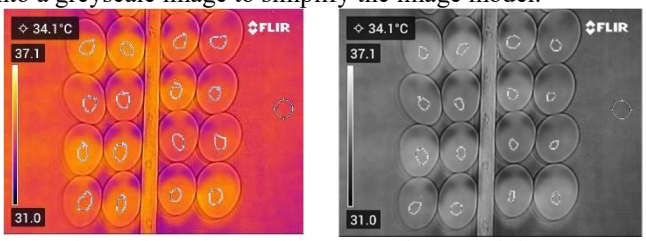
Fig 4. 5th day image

In this study, the main feature that becomes an important component is color. The color of the object is the main feature because the image used is a thermal image. Thermal image is the result of a representation of a temperature state that is displayed with different colors. The higher the temperature on an object, the brighter the color displayed. Thermal images that have been obtained from data collection for 15 day will be average greyscale value which will be converted into a temperature. The next process is to label the temperature processed using MATLAB software. The first processing is to cut the color palette contained in the image and then change the color palette from an RGB image to a grayscale image.

a. RGB color palette cropped image b. Grayscale cropped image

Fig 5. Image color palette

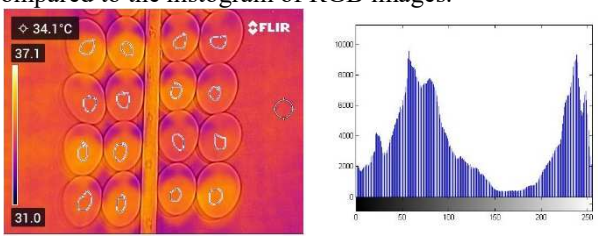
The next processing is to determine the ROI (Region of Interest) in the image. In this study ROI is used to filter the part of the egg which will later be converted into a temperature. The RGB image that has been determined will be converted into a greyscale image to simplify the image model.



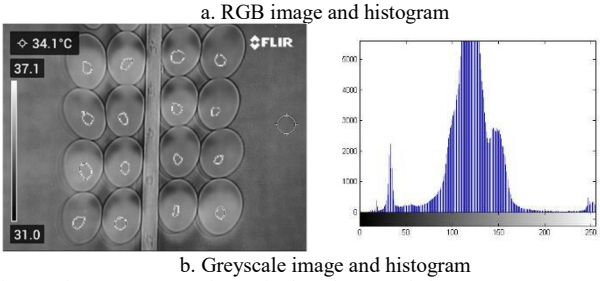
a. RGB image after ROI processing b. Greyscale image

Fig 6. Image Processing of ROI

The sample used in this study is an image of group eggs consisting of 16 (sixteen) eggs in one image. Based on Figures 7 histogram comparison between RGB images and grayscale images is carried out and it can be seen that by using grayscale images, the color intensity is more evenly distributed when compared to the histogram of RGB images.



a. RGB image and histogram



b. Greyscale image and histogram

Fig. 7. Histogram comparison of rgb and greyscale images

The next process is to translate the image color into temperature. After getting the ROI area, each area will have average greyscale value which will be converted into a temperature. The next process is to label the temperature information on the egg image group consisting of 16 (sixteen)

eggs using the ROI area which is translated into a rectangle as shown in the figure.

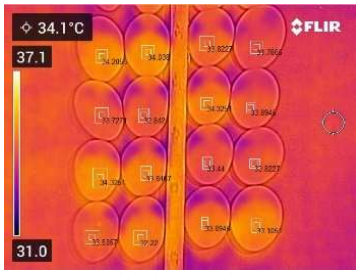


Fig 8. Image labeling results

B. Discussion

In this study, 16 egg samples were used to determine the characteristics of fertile and infertile eggs. All samples used in this study were given the same treatment between eggs with one another. Starting from the preparation process includes selecting eggs based on physical shape, cleaning the egg shells, and preparing the incubator machine. The process of rearing eggs, which is the object of this research, is also very important, starting from the conditions of temperature, humidity, cleanliness, and egg turning time.

Based on the results data that have been obtained and processed, the temperature characteristics of fertile and infertile eggs were found in this study. These temperature characteristics were obtained through observation and analysis of the resulting data. In this study, it was found that there were differences in temperature characteristics between fertile and infertile eggs, namely changes in egg temperature every day. Table 1 is the result of temperature for egg number 4 and egg number 5 obtained based on the processing steps that have been carried out.

TABEL 1. RESULTS OF TEMPERATURE MEASUREMENTS USING A THERMAL CAMERA

Days	4th Egg temperature (Infertile)	5th Egg temperature (Fertile)
5	32,4°C	33,7°C
6	31,9°C	32,9°C
7	34,9°C	37,2°C
8	33,2°C	36,6°C
9	35,3°C	35,2°C
10	35,5°C	36,7°C
11	35,6°C	36,9°C
12	35,8°C	37°C
13	35,4°C	37,5°C
14	35,2°C	37,4°C
15	35,9°C	36,7°C
16	35,6°C	39,1°C
17	34,7°C	38°C
18	34,7°C	39,3°C
19	36,2°C	39,5°C

Comparison of egg temperatures can be seen by comparing egg number 4th and egg number 5th. From the observations, the first characteristic that distinguishes fertile and infertile eggs lies in the tendency of increasing temperature every day. From the two samples that have been processed, it shows that there is a tendency to increase the temperature every day for fertile eggs while the temperature will tend to be stable or decrease every day for infertile eggs. It can be seen in Figure 9 which is a comparison of egg number 4th (infertile) and egg number 5th (fertile), the temperature value for fertile eggs is higher than the temperature for infertile eggs. This is because in egg number 5 there is embryonic development of the egg until it hatches, while in egg number 4 there is no embryo development.

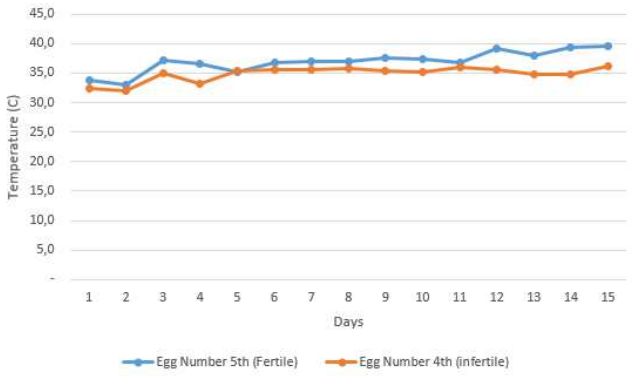


Fig 9. Graph of temperature comparison for egg number 4th and egg number 5th

Based on the process of observation and analysis of the data on fertile eggs and infertile eggs as a whole, it can be stated that for fertile eggs, the pattern of changes in temperature values on the graph tends to increase more steadily than the pattern of changes in temperature values on the graph of infertile eggs which tends to be unstable. So the temperature of the fertile egg is higher than the temperature of the infertile egg.

V. CONCLUSION

From the results of the research that has been done, it can be concluded that the temperature characteristics in this study are divided into two, namely fertile eggs will experience an increase in temperature which tends to be stable every day while infertile eggs the temperature value tends to be unstable. The distinguishing characteristic between fertile chicken eggs and infertile chicken eggs is that the temperature value of fertile eggs when approaching hatching is always higher, which is >38C° compared to infertile eggs which only reaches 36C°.

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