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Otsu Method for Chicken Egg Embryo Detection based-on Increase Image Quality

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ABSTRACT

Detection of chicken egg embryos using image processing has limitations and needs some processes for improvement. By human vision, the previous process used binoculars and candling using light/beams directed at the chicken eggs in the incubator. In this study, we propose the application of image segmentation using the Otsu method in detecting chicken egg embryos. This method uses image segmentation with increased image quality (preprocessing) by several methods such as resizing, grayscaling, image adjustment, and image enhancement. These processes produce a better image and can be used for input in the segmentation process. In addition, this study compares several segmentation methods in detecting chicken egg embryos, such as thresholding, Otsu basic, and k-means clustering. The results show that our proposed method produced segmentation images to detect chicken egg embryos of 200 datasets images. This method has a faster process and can create a uniform segmentation than other methods. However, other methods can also detect chicken egg embryos. The methods accuracy proposed in this study increased by 1.5% compared to other methods. In addition, the resulting SSIM value has a percentage close to and more than 90%, which means that the segmentation of the results obtained can be used to detect chicken egg embryos.

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1. INTRODUCTION

Image segmentation can detect objects by dividing certain areas, such as the background and the object itself. The application of one of these image processing methods is in the livestock industry. The implementation of the segmentation can be used to detect chicken egg embryos [1] in incubators. This process is carried out in the first week [2] during hatching to maximize the hatching process. Embryo development of chicken eggs that are not visible are removed from the hatchery, and eggs that have embryos remain in the incubator until the hatching process is complete [3] . This process is a solution for sorting or checking the presence of chicken egg embryos which were initially only done using human assistance. Along with the development of technology and research in the field, the process has been developed using computerization by applying image processing.

The implementation of image processing in detecting egg embryos can be done by classification, clustering, and segmentation [4–8]. The detection of egg embryos in previous studies used several methods such as segmentation [9–11] and machine learning [12]. The images used are datasets of acquired images from the acquisition process with tools, namely smartphone cameras and LED lights (candling process [13]). Thus, the image used as input for this research is the image of a chicken egg that shows the eggs contents. This image shows the presence or absence of a chicken egg embryo. In this study, the concept used is segmentation by applying the simple method (Otsu). The improved process is the image preprocessing part, so the point of improvement is improving the image quality. The preprocessing image is the input in the image segmentation.

The image is converted into a black and white image in the segmentation process. This conversion process uses a certain threshold which is calculated automatically based on the value of the distribution of the image pixels, using the otsu method. However, the input from the image resulting from image preprocessing is a measure of success in segmentation. The methods implemented include image resizing, image adjustment, and image enhancement. Image enhancement in this study uses two methods, namely Histogram Equalization (HE) and its derivatives (Contrast Limited Histogram Equalization/CLAHE). This process is different from previous studies using segmentation methods such as k-means and morphology [10, 14], thresholding [11], otsu [15], fuzzy logic [16], watershed [17], region generation [18], and Differential Interference Contrast (DIC) based on Shape Index and Ellipsoid-Fitting [19].

This study aims to detect the presence or absence of chicken egg embryos in an incubator with image processing that displays a digital image. Processes mostly done manually can be implemented using a computer to be processed quickly. In addition, despite many related studies, we propose a simple concept of segmentation to represent these embryos. The concept is carried out by improving image size, object detection, and image quality improvement. Thus, we propose improvements in the image preprocessing process to improve image qualityimproved image quality previously processed by cropping, resizing, and grayscaling. During the image segmentation, we use the otsu method. Thus, this research focuses on applying the Otsu method in segmentation by improving image quality (image preprocessing) in the input.

This study presents four main stages: introduction, method, results and discussion, and conclusion. This section describes the background of the problem, the research gap, and its objectives. The solution is carried out by applying the image processing methods presented in the second part. The third section presents the analysis of the results and discussion of this research. The last part is the conclusion.

2. RESEARCH METHOD

This section describes image processing in segmenting images using the Otsu method to detect chicken egg embryos. This research carries several process stages, such as image acquisition, image preprocessing, and image segmentation. The three primary process stages are described in detail as in Figure 1. In addition, each primary process is described in detail in the chart. Finally, it produced an image of a chicken egg with a segmented embryo.

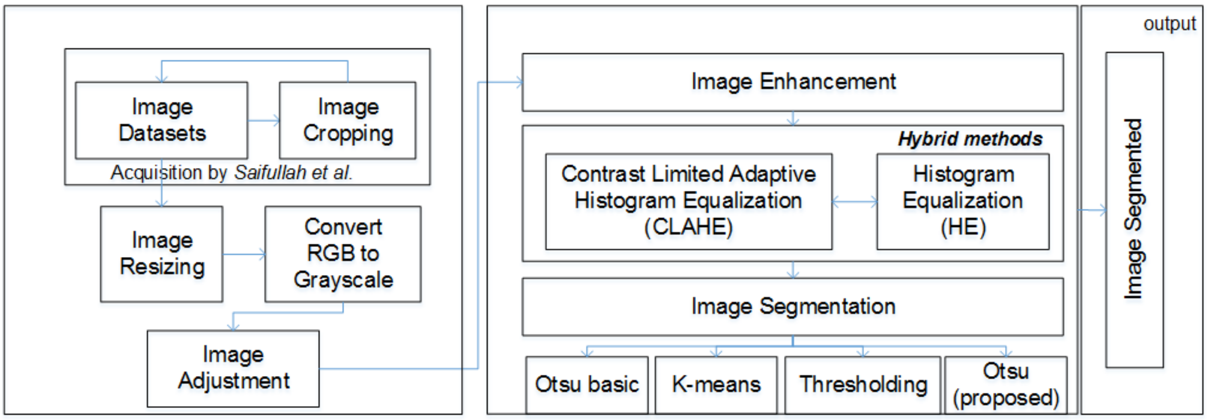


Figure 1. Image segmentation process to detect chicken egg embryos

2.1. Datasets and Grayscaling

The image dataset is a cropped color image (RGB) [1]. The egg image is obtained from the image acquisition process using a smartphone camera with an egg object attached [10]. The total amount of data used is 200 eggs with 100 each of fertile and infertile eggs. The datasets were captured with the process and results, as shown in Figure 2 from the free-range chicken egg. All image preprocessing processes in this study are image grayscaling, image adjustment, and image enhancement [9, 20]. Image grayscaling is a method for converting RGB images to grayscale. RGB images have 3 color channels, namely red (R), green (G), and blue (B). The conversion process uses (1) [21] to get a gray level color gradation with a value range between 0-255.

$$gray = 0,2989 * R + 0,587 * G + 0,1141 * B \tag{1}$$

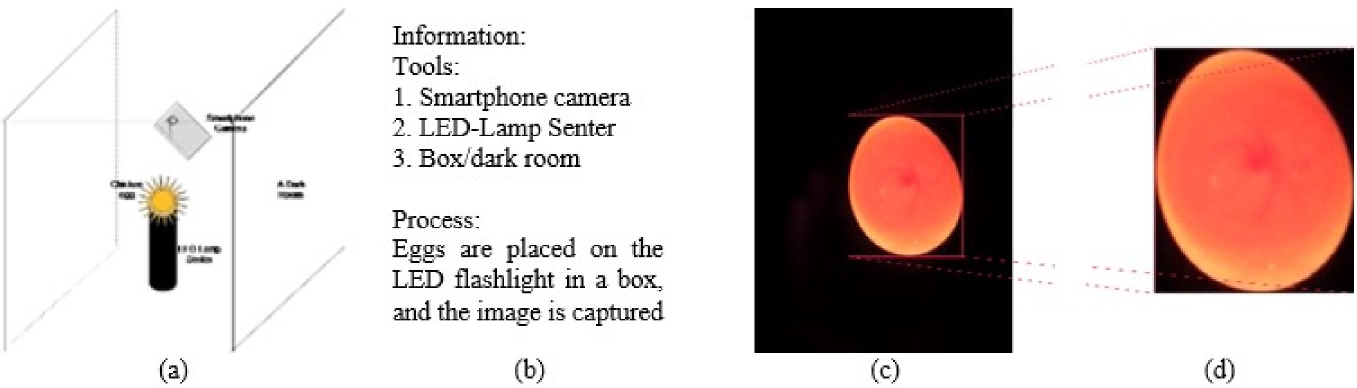


Figure 2. (a) Acquisition process design using (b) details of tools and candling process with (c) RGB image and (d) cropping

Figure 2 shows the acquisition process of datasets that have been carried out in previous studies and produced the image used in this study. The acquisition process using tools (such as the details in Figure 2 (b) produces a color image with a black background as in Figure 2 (c). The acquisition results are automatically cropped using the background and the object [22]. So that the cropping results produced in detail only show the chicken egg object as shown in Figure 2 (d) [23].

2.2. Image Preprocessing with Image Adjustment

Grayscale images need to be processed using image adjustments to see images with fewer gradations more clearly. Image adjustment maps the intensity value I to the new value J from the lowest and highest image intensity values to the lowest and highest typical intensity values.

Image adjustment uses the linear mapping method to get a new intensity value from the histogram of the image used. Image adjustment uses the calculation of the factor value (F) of the image contrast correction (2), which has a floating-point value. The value of C indicates the level of contrast. So this process is continued by using a contrast enhancement (R) on each color component (3).

$$F = \frac{259(C + 255)}{255(259 - C)} \tag{2}$$

$$R' = F(R - 128) + 128 \tag{3}$$

2.3. Image Preprocessing with Image Enhancement

The result of color improvement with image adjustment is used as input for image enhancement [24]. Image enhancement uses two combined methods of Histogram Equalization (HE) and its derivative, namely Contrast Limited Adaptive HE (CLAHE). The use of this method is based on previous research, that the resulting image shows better results than the single method or other combinations [11, 20, 17]. This process modifies the histogram of the image. The calculation of the two methods uses (4) for HE and (5) for CLAHE. The next step is to combine the two using (6) to get a better image from these methods.

$$hi = \frac{n_i}{n}, i = 0, 1, 2, , L - 1 \tag{4}$$

$$\beta = \frac{M}{n}(1 + \frac{\alpha}{100}(S_{max} - 1)) \tag{5}$$

$$hybridCLAHE - HE = \beta \oplus h_i \tag{6}$$

HE improves image quality by histogram (hi) smoothing the image [25, 26]. The image matrix is used to get the total number of pixels (n). This method divides the image based on the number of gray pixels (ni) with pixels up to the maximum gray value (L). CLAHE is an extension of HE [25] with a limit value based on the maximum height of the histogram [27]. The constraint applies the clip limit formula (β) to obtain contrast based on the kernel weighting of each neighboring pixel (5). Thus, the CLAHE method can eliminate noise and improve its quality, and this clip boundary uses the area size (M), grayscale value (N), and clip factor (α) in addition to the histogram boundary (0-100). Based on previous research, the comparison of the HE and CLAHE methods and their hybrids, where the different histograms show the differences in the image the best distributed histogram [28] is used in the segmentation method. Hybrid CLAHE-HE has an optimal histogram spread [11].

2.4. Image Segmentation

Segmentation based on object and background will divide the image into two parts, namely foreground, and background [28]. In this study, the segmentation process uses the results of image quality improvements. This process only uses the conversion of a grayscale image into a BW image [29, 30], by changing the value of a grayscale image (range 0-255) into a BW image with a limited median value or certain threshold. Matrix values above 128 are changed to 255, and below 28 are converted to 0. So the resulting value can be converted into binary values (0 and 1) [31].

The otsu method is a segmentation method that automatically divides the grayscale image histogram into two classes without entering a threshold value [34]. Thus, the threshold value is automatically calculated and will minimize the class variance used as the weighted sum of the two classes (7). The weight values ω_0 and ω_1 are the probabilities of the two classes with a certain threshold value based on the variance value of the two classes (σ_0^2 and σ_1^2).

$$\sigma_\omega^2(t) = \omega_0(t)\sigma_0^2(t) + \omega_1(t)\sigma_1^2(t) \tag{7}$$

Based on the image histogram (grayscale), the class probability is calculated from the L value (grey level with a range of 0-255) in the histogram (8) and the calculated threshold (t). The process of minimizing class variance is the same as maximizing interclass variance using (9), where ω is the class probability value and μ is the class average.

$$\omega_0(t) = \sum_{i=0}^{t-1} p(i) \;\&\; \omega_0(t) = \sum_{i=0}^{L-1} p(i) \tag{8}$$

$$\sigma_b^2(t) = \sigma^2 - \sigma_\omega^2(t) = \omega_0(\mu_0 - \mu_T)^2 + \omega_1(\mu_1 - \mu_T)^2 = \omega_0(t)\omega_1(t)[\mu_0(t) - \mu_1(t)]^2 \tag{9}$$

The class average can be calculated using (10). The average value is calculated based on the probability value and histogram. At the same time, the relationship between the value of the opportunity and the class average is shown (11).

$$\mu_0(t) = \frac{\sum_{i=0}^{t-1}(i)}{\omega_0(t)} \;\&\; \mu_1(t) = \frac{\sum_{i=0}^{t-1} p(i)}{\omega_1(t)} \;\&\; \mu_T = \sum_{i=0}^{L-1} ip(i) \tag{10}$$

$$\omega_0\mu_0 + \omega_1\mu_1 = \mu_T \longleftrightarrow \omega_0 + \omega_1 = 1 \tag{11}$$

Implementing the Otsu method is carried out with the following steps.

1. Calculate the histogram value and the probabilities of the image intensity.
2. Calculate the initial value of $\omega_i(0)$ and $\mu_i(t)$
3. Calculates all possible threshold values $(t = 1, ..., L)$
4. Update the values of ω_i and μ_i
5. Calculating the value of $\sigma_b^2(t)$
6. Finding the maximum value of point 3. b as the value to be used

In addition to the Otsu method, this study compares the segmentation methods that have been carried out by previous researchers, such as Thresholding, K-means (color and grayscale), and Otsu basic. The comparison is based on segmentation, SSIM calculations, and Accurate.

3. RESULT AND ANALYSIS

This section presents the results and analysis of the research process from image preprocessing to the SSIM calculation process and accuracy. As described in Figure 3 (stage of the detection process), the experimental results are presented and discussed. The experimental process uses datasets from previous studies and uses Matlab Simulink Tools. Initial analysis on image preprocessing was compared with several methods and other studies (previous), which resulted in the improved image for the segmentation process [32]. In addition, the results of segmentation using the Otsu method based on the proposed image preprocessing are presented with segmentation analysis in embryo detection. The segmentation results are also compared with several segmentation methods that have been carried out in detecting chicken egg embryos, such as thresholding, basic otsu, and k-means segmentation.

3.1. Analysis of Image Preprocessing

Image preprocessing uses several images resizing, image adjustment, and image enhancement methods. Image resizing by reducing the image size speeds up the image processing (smaller than the original image). Based on the image data-set (Figure 2 (d)), the first image preprocessing is image resizing. Image resizing changes the image size from 655x545 pixels to 0.2 of its pixel size. Digitally, the image is seen at a smaller size. In the process, the small size of the resulting pixels can speed up the image processing [30]. The image is represented by a matrix with a value range of 0-255. Suppose the color image has three color components, namely Red, Green, and Blue (RGB). Thus, the image needs to be converted into a grayscale image using formula (1).

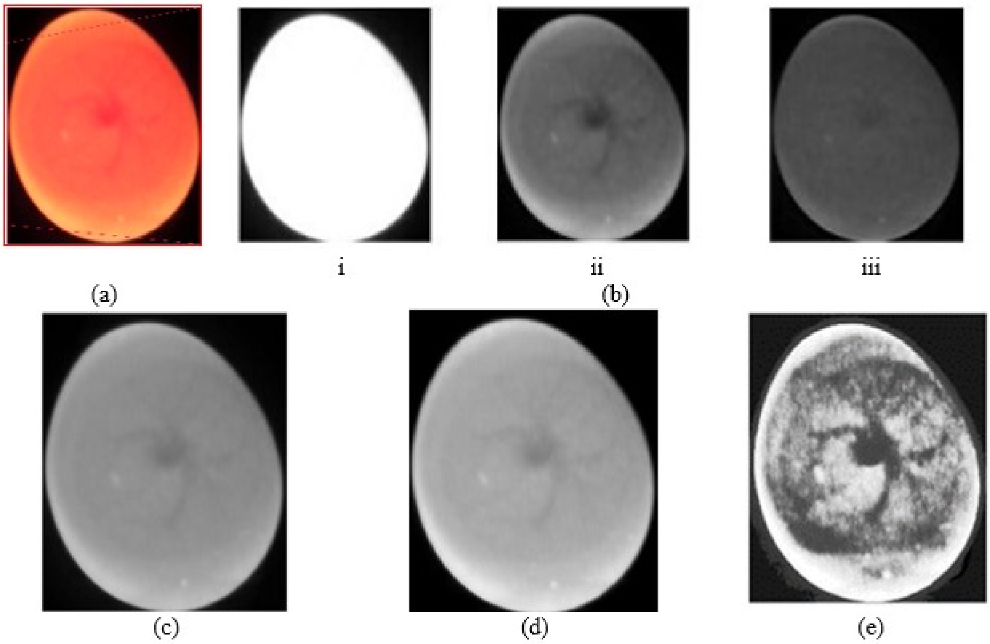


Figure 3. Image Processing Results Based on Image Preprocessing Experiments with (a) Cropping (based on the concept of segmentation), (b) Grayscaling with color i. red ii. Green and iii. Blue, (c) Image Grayscale, (d) Image Adjustment, and (e) Image Enhancement (CLAHE-HE)

Image preprocessing uses color image datasets (Figure 3 (a)) which has 3 color components separated into 3 as in Figure 3 (b). each image with a specific color has a matrix that is calculated using (1) so that it becomes 3 (c). As for the calculation sample, we use the process of resizing the original image into an image size 4x6, as shown in Figure 4 (a)-(c) for each image channel sequentially.

42	196	133	5
170	255	255	91
235	255	255	197
241	255	255	237
180	255	255	200
50	222	237	65

(a)

18	94	51	0
71	103	88	25
94	89	83	63
103	98	89	89
91	113	107	95
25	132	137	34

(b)

11	58	35	0
46	76	69	21
67	75	72	50
71	78	74	64
57	81	78	59
16	79	83	20

(c)

24	120	74	1
98	145	136	44
133	137	133	102
141	143	137	130
114	152	148	122
31	153	161	42

(d)

Figure 4. An example of the grayscaling process on a 4x6 resizing image matrix from each color component (a) red, (b) green, and (c) blue to produce (d) a grayscale image matrix

An example of the calculation, for example from Figure 4 (a) matrix [1,1], Figure 4 (b) matrix [1,1], Figure 4 (c) matrix [1,1] is calculated by (1) resulting in:

$gray = 0,2989 * R + 0,587 * G + 0,1141 * B$

$gray = 0,2989 * 42 + 0,587 * 18 + 0,1141 * 11$
$gray = 12.5538 + 10.566 + 1.2551$
$gray = 24.3749 \approx 24$

Each process is calculated to obtain the matrix results, as shown in Figure 4 (d). The results of these calculations are in the form of integers or integers. So if it produces a fraction, it is rounded up, as in the calculation of the [1,1] matrix. After the grayscaling process, the next step is image adjustment by increasing towards 255, as shown in Figure 5. The image adjustment process uses (2) and (3) so that from a grayscale image (histogram as shown in Figure 5 (a), it turns into a histogram with a distribution of graphic values as in Figure 5 (b). The histogram stretches to the right and left.

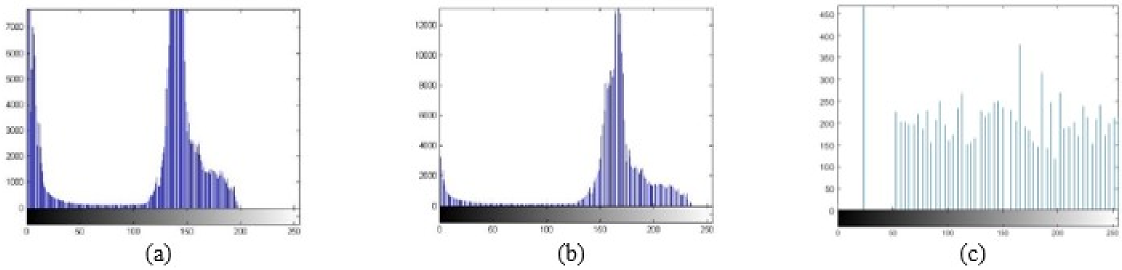


Figure 5. Histogram of (a) grayscale image processed with (b) image adjustment and (c) Image enhancement (CLAHE-HE)

The histogram distribution needs to be manipulated with Image Enhancement using histogram alignment (CLAHE-HE) [11, 20]. This method can improve the quality of the image. It looks clearer as in Figure 3 (e) with the histogram distribution as in 5 (c), where the value is reduced, resulting in a lower and even histogram value.

3.2. Results of Otsu Method on Image Segmentation

The results of image preprocessing (Figure 3 (d)) become input in the segmentation of the Otsu method. The segmentation process uses several initial variables, such as the grayscale image histogram (from the image enhancement results). The variables used in the Otsu method process are shown in Table 1.

Table 1. Variables in the otsu method to get an automatic threshold

Variable	Value of Grayscale	
	Basic	Increase image quality
Number of histograms	13000	13000
Size (level)	256	256
Total w (initial-end)	0-1428371	0-1658257
wF (end)	0	213
wB (initial)	65	15
wF (initial) = wB (end)	13000	13000
Otsu (threshold)	80	131

The application of the Otsu method in the proposed method has a better value than the basic grayscale image. From the sample used, the resulting threshold is 131 (mean value). Based on these results, the image of Figure 4 (d) is changed to be as in Figure 6 (the result of segmentation).

Figure 6. The results of segmentation based on image enhancement (CLAHE-HE)

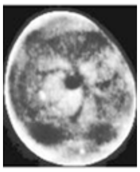
The segmentation uses the BW conversion method and its complement to obtain an image that detects the chicken egg embryo object. The segmentation process is carried out using the complement of the CLAHE-HE repaired image, as shown in Figure 6. The image shows a negative image. The image matrix is changed by using the maximum grayscale image threshold (255) minus each matrix value.

In this study, the segmentation is converting grayscale images into black and white images. The change process is based on the threshold value calculated by Otsu, as shown in Table 1 of the gray level (131). The intensity value of more than 131 is converted to 255, while the others will be 0. This segmentation produces a BW image, as shown in Figure 6. This conversion also shows a binary image conversion, where the resulting intensity values have values of 0 and 255, which are changed to 0 and 1. Range 0 and 1 look like in Figure 6.

3.3. Comparison of the Methods of Image Segmentation on Chicken Egg Embryo Detection

The results of the segmentation of the proposed method are compared with previous studies with the same data. The process according to each study is shown in Table 2. Based on the image obtained, the proposed methods processing results have a clear image, and speed access is limited. All results have clarity of detected embryo objects, but the basic otsu method still looks blurry, so the image quality needs to be improved by using image preprocessing as we proposed.

Table 2. Variables in the otsu method to get an automatic threshold

Methods	Thresholding [11]	Otsu basic	Kmeans-LAB [14]	K-means [10]	Otsu and increase quality (proposed)
Segmentation Results					
Information	Clear	Blur and object detected	Clear	Clear	Clear
Times	0.57	0.89	10.6	(Resizing) 26.52; [(No iteration) 213.43] & [(Max. iteration) 106715.23]	0.43

Based on the segmentation results in Table 1, the segmentation that has been carried out can be used as a reference in detecting egg embryos and can be used to sort out the development of these embryos in the incubator. However, our proposed method is faster than previous studies in terms of access time.

3.4. Structure Similarity Index Methods (SSIM) and the Accuracy Calculation

In this study, SSIM is used to determine the structural equation of the original image converted into a black and white image with the research process carried out. The comparison results obtained the distribution for the images of embryonated (fertile) and non-embryonic (infertile) eggs, as shown in Table 3.

Table 3. Results of each SSIM

Methods	Variable	Distribution of SSIM	Average of SSIM
Thresholding [11]	Fertile Infertile	0.931-1	0.924
Otsu basic	Fertile Infertile	0.896-1	0.916
Kmeans-LAB [14]	Fertile Infertile	0.925-1	0.997
K-means [10]	Fertile Infertile	0.996-1	0.999
Otsu and increase quality (proposed)	Fertile	0.923-1	0.951
	Infertile	0.897-1	0.903

The distribution of values obtained by the variables has an average of above 0.9 and is close to 1. This value indicates that the resulting difference is that the information obtained does not change, where the structure of the research results is almost the same as the original image so that the processed information does not change much.

In addition to checking the SSIM, accuracy is also calculated. Accuracy is obtained from comparing results carried out with various methods and manuals with these results. The Otsu method with improvements proposed in this study has an accuracy value commensurate with other methods. In addition, the process is faster because it uses basic concepts and improves image quality using copped and resized images. The accuracy calculation obtained in this study is the same as the previous study, namely 96% [20] for the same data. However, in this study, 2x training and testing data were added. So that the resulting percentage increases to 97.5%.

4. CONCLUSION

Based on the results of this study, the otsu method with improved image quality was able to segment the image of an embryonic egg. The segmentation is able to provide black and white images that clarify the presence or absence of chicken egg embryos. The final image is in a black and white image that distinguishes the object from its background. In particular, the details of the object are embryos that are detected in detail in their parts. Comparison of segmentation methods such as thresholding, otsu basic, and k-means has an SSIM evaluation distribution with a good value approaching 90% and above. If it is closer to 100%, this value indicates that the results of the comparison with the results of the previous image are close to or the same. It shows that the segmentation can be implemented to detect the presence of chicken egg embryos. In addition, our proposed method has a faster processing time than the others, namely 0.43 seconds, and an increase in accuracy of 1.5% (from 96% to 97.5%)on the segmentation process of the datasets used compared to other methods. For future works, the method will be combined with machine learning algorithms to increase the specific object on image segmentation.

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