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Evaluation of Morphological Operation Structure Elements for Eggs Identification in Gonad Ultrasound Image

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Abstract There are various type of radiology imaging such as ultrasound image, computed tomography (CT), magnetic resonance imaging (MRI) and plain x-rays. These imaging are widely used in medical field in term of to diagnose and treat disease. Radiology imaging also can be used in aquaculture field where ultrasound image is used to identify eggs in fish gonad. However due to the characteristic of the eggs in the gonad ultrasound image is small and different size at the same time lead to difficulties in identifying the eggs. Based on these characteristics, the morphological-based segmentation is applicable in segmenting the eggs in ultrasound image because this method is useful for describe and segment the region shape especially in the small objects.

Keywords: **Radiology imaging technology; ultrasound image; morphological-based segmentation**

1. Introduction Ultrasound imaging is a radiology imaging technology that uses sound waves to produce pictures of the inside the body [1]. In aquaculture, ultrasound imaging has been used to study the internal structure such as the inner structure of small fishes [2]; blood flow and vein contractions in the common cuttlefish Sepia officinalis [3] and disease, such as swim bladder nematode Anguillicoloides crassus infestation in European eels Anguilla anguilla [4]. Ultrasound imaging has also been used to study the fish reproduction and sex identification of many valuable freshwater and marine fish species, such as sturgeon [5].

In this research paper, the focus is on the eggs identification in ultrasound image. The characteristic of the eggs in the gonad ultrasound image is small and different size at the same time. These characteristics contribute to the difficulties of using the current segmentation framework which is focusing on the large segmenting organ such as fetus [6], brain [7], breast [8] and many more. In order to identify and segment the eggs in the fish gonad ultrasound image, segmentation method is used.

Prior to that, the discussion on the pre-image processing of gonad ultrasound image has been published in [11]. There are many segmentation methods that can be used such as threshold-based, edge-based and morphological-based. In this research paper, morphological-based segmentation is used to identify the eggs in the fish gonad ultrasound image because this segmentation method is useful for describe and segment the region shape especially in the small objects. Morphological image processing is a collection of non-linear operations related to the shape or morphology of features of an image. This morphological operation uses structuring element to measure the shape of the given image and then carry out the image processing. This structuring element applies to all possible locations of the input image as generating the same size output. In this morphological-based segmentation, there are operators namely dilation and erosion, and the morphological reconstruction namely filling the holes and clear the border as explain in [10]. These operators work depends on the structure elements used in the morphological operation process. There are many structure elements that can be used such as diamond, disk, line, square, octagon and rectangle. This research paper emphasize on the performance of structure elements towards identifying eggs in the gonad ultrasound image.

This structure element consists of a matrix of 0's and 1's, typically much smaller than the image being processed. The center of the pixel of the structure element, called the origin, identifies the pixel being processed as shown in Figure 1.

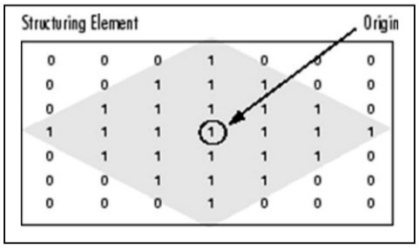


Figure 1: Example of simple structure element of diamond 3x3 element.

Figure 2 shows the difference of structure element with different type of size. Diamond, disk and octagon as shown in Figure 2 (a), (b) and (c), used R as the distance between the origins to the side of the shape. While, for line structure element used LEN as the distance of the line and DEG specifies the angle of the line as measured in counterclockwise direction from the horizontal axis as shown in Figure 2 (d). Structure element of square used W to measure the width of the shape as shown in Figure 2 (e).

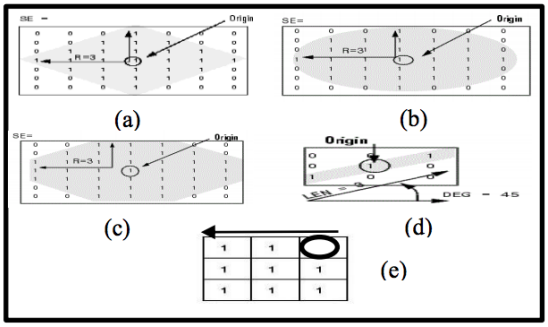


Figure 2: Example of simple structure element with the size of 3x3. (a) Diamond shape with R (b) Disk shape with R (c) Octagon shape with R (d) Line shape with LEN =3 and DEG = 45°, and (e) Square shape with W

2. Experimentation Setup Morphological image processing is a collection of nonlinear operations related to the shape or morphology of features of an image [10]. The advantages of using the morphological approach are particularly useful for analysis of binary images, boundary detection, noise removal, image enhancement, and image segmentation. The most basic morphological operation is dilation and erosion. Morphological operations apply structure elements in the dilation and erosion process to an input image and creating an output image of the same size. The experiment below is to evaluate which structure elements that suitable to use in the dilation and erosion process in identifying eggs in gonad ultrasound image.

A. Experimental setup on selecting suitable structure elements in morphological operation

In this experiment, structure elements which are diamond, line, square, and disk with different size of the element as shown in Table 1 have been experimented and compared. In order to evaluate the structure elements, the results will be compared with the benchmark image as shown in Figure 3. This benchmark image is used to compare the selection of eggs by the expertise with the selection of eggs identified by using different type and parameters of structure elements. This benchmark image contain of 62 eggs as highlighted in red circle. These eggs have been manually select by the expertise from AgroBiotechnology Institute (ABI), MARDI.

Table 1: Types of structure elements and parameters used in the experiments

SHAPE	PARAMETER
Diamond Disk	R = 2, 4, 6, 8
Line	LEN = 2, 3, 4 DEG = 90°, 180°
Square	W = 2, 4, 6, 8

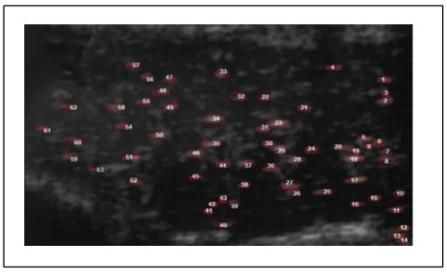


Figure 3: Benchmark image of 62 identified eggs in the fish gonad.

The experiment execution is based on the type of structure elements and the parameters shown in Table 1 and evaluation is based on confusion matrix where

- True Positive (TP): The result has the eggs, and the expert's result does have the eggs.
- True Negative (TN): The result doesn't detect the egg, and the expert's result also doesn't detect the egg.
- False Positive (FP): The result do detected the eggs, and the expert's result doesn't have the egg.
- False Negative (FN): The result doesn't detect the egg, but in the expert's result do have the disease.

B. Evaluation method

i. Precision and Recall

In information retrieval, precision (also called as positive predictive value) is the fraction of retrieved instances that are relevant, while recall (also known as sensitivity) is the fraction of relevant instances that are retrieved. From the confusion matrix, the precision and recall are calculated based on the equation (1).

$$precision = \frac{tp}{tp + fp} \qquad (1)$$

$$recall = \frac{tp}{tp + fn} = sensitivity$$

Precision can be described as a measure of classifiers exactness, while, recall can be describe as a measure of classifiers completeness. A low precision can also indicate a large number of False Positives and a low recall indicates many False Negatives.

ii. F-measure

F-measure is a formula to measure test's accuracy. The calculation involves precision and recall as depicted in equation (2).

$$F = 2\,x\,\left(\frac{precision\ x\ recall}{precision + recall}\right) \qquad (2)$$

F-measure also can be interpreted as a weighted average of precision and recall, where F-measure reached its best value at 1 and worst at 0.

iii. Accuracy

Accuracy refers to the closeness of measured value to a standard or known value. It also can be called as the percentage of correctness rate in the research. The calculation can be defined as shown in equation (3).

For example given 100 example data as test data and during classification process only 70 data is correctly classified, therefore the accuracy is 70%.

$$Accuracy = \frac{tp}{Total\ of\ test\ data} x\ 100 \qquad (3)$$

3. Results The experiment is prepared to find the suitable structure elements and size that can be used in the morphological operation. In this experiment, four structure elements have been used which are diamond, line, square and disk with different size of the element. The selection of structure element in the morphological operation is essential to create an output image of the same size in dilation and erosion process. In order to evaluate which structure element is suitable to use, the results of the experiments will be compared with the benchmark image as shown in Figure 3. This benchmark image is the ultrasound image that the eggs have been marked by the expertise.

A. Structure Elements

As previously explained, the structure elements of diamond and disk used the distance between the structuring element origins to the side of the shape as the element size of the shape. While, for square shape, the width of the shape is the element size of the shape. As for line structuring element shape, LEN as the distance of the line and DEG specifies the angle of the line in counterclockwise direction are the element size of the shape. The element sizes used for diamond, disk and square are 2, 4, 6 and 8. While, for line, the element size used for LEN as the distance of the line are 2, 3 and 4, and for DEG specifies the angle of the line in counterclockwise direction are 90° and 180° as shown in Table 1.

In the experiment there will be two structure elements used in the morphological operation which each is for dilation and erosion process. Image 1 from Table 2 shows that diamond and disk elements identify less eggs and most of the eggs were removed. While, Image 2 shows the dilation using disk with element size of 8 followed by erosion using square with element size of 2 and with these elements show that there are many connected egg segment circle in the image.

As for Image 3 it shows the dilation using square with element size of 2 followed by erosion using line with element size of LEN = 3 and DEG = 90°, and with these elements show there is other objects segmented other than eggs such like the gonad wall which lead to false identification of eggs. However, for Image 4 shows the dilation using line with element size of LEN = 4 and DEG = 90° followed by erosion using line with element size of LEN = 3 and DEG = 180°, and the combination of structure elements Line with different parameters identified most of the eggs in the gonad. From the results of the experiment, the eggs are counted to get the best structure element for the morphological operation algorithm. The result of the counted eggs of this experiment can be seen in the Table 3.

Table 2: Several results from vary structure elements and parameters used in the experiments

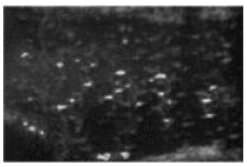
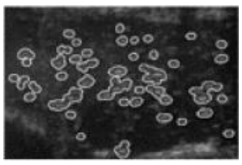
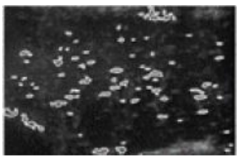
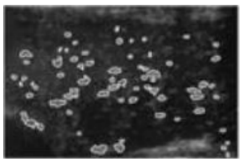
Image 1: Results of dilation using structure element **diamond** shape with element **size of 2** followed by erosion using **disk** with element **size of 6**.	
Image 2: Results of dilation using structure element **disk** with element **size of 8** followed by erosion using **square** with element **size of 2.**	
Image 3: Results of dilation using structure element **square** with element **size of 2** followed by erosion using **line** with element **size of (3, 90°).**	
Image 4: Results of dilation using structure element **line** with element **size of (4, 90°)** followed by erosion using **line** with element size of **(3, 180°).**	

Table 3: Eggs counted for every structure elements used in dilation and erosion process in morphological operation

PARAMETER: DILATION → EROSION				
DILATION	**EROSION**			
	Diamond	Disk	Square	Line
Diamond	39	39	38	38
Disk	39	36	34	37
Square	4	34	36	38
Line	27	25	35	**44**

As mention previously, confusion matrix is used to formulate the precision, recall, F-measure and accuracy of the final output of this research. This confusion matrix is included the True Positive (TP), False Positive (FP) and False Negative (FN) and the result shown in Table 4.

From the values in Table 4, precision, recall and the accuracy rate can be calculated as shown in Table 5.

Table 4: Table truth of Confusion Matrix

Confusion Matrix	
No. of eggs identified in the benchmark image (N)	62
True Positive (TP)	44
False Positive (FP)	21
False Negative (FN)	17

Table 5: Result of Precision, Recall, F-measure and Accuracy rate

Precision	0.682
Recall	0.726
F-measure	0.703
Accuracy	73%

4. Discussion and Conclusions In conclusion it shows that the dilation with line shape followed by erosion with line shape have the highest values of eggs counted compared to the other structure elements which identified 44 eggs out of 62 in the gonad ultrasound image. Therefore, the structure elements of line is used for dilation with the element size of LEN = 4 and DEG = 90° followed by erosion using line with element size of LEN = 3 and DEG = 180° with the accuracy of 73% is used in the research and also were justified by the experts.

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