Automated Fish Egg Counting System using Image Processing

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ABSTRACT

The fish industry is a source of income for fish breeders. Fish egg selection is one of the important aspects in determining the quantity of fish eggs. The quantity of fish eggs purchased from practitioner may be insufficient due to undetected poor quality of fish eggs. Hence, this study focuses on automated fish egg counting system using image processing method utilizing *k*-means algorithm. The image of fish egg are captured and processed to calculate the total number of fish egg automatically. The results demonstrate good potential use of the proposed automated counting system with accuracy up to 99.41%. Furthermore, with the proposed automated counting, the manual counting time can be reduced to an average time of 1.29 seconds. This could benefit the fish breeding industry in screening good quality of eggs automatically.

Keywords: automated counting system, image processing, fish egg, k-means algorithm.

I INTRODUCTION

The fisheries sector plays a major role in Malaysia's economy, as a source of income and employment. It is also one of the foreign exchange markets Fish is normally consumed by races in Malaysia and plays a crucial role as a source of protein in daily diet. Based on the Third National Agricultural Policy (NAP 3), the fish demand and fishery products are expected to continue to rise substantially due to high population growth and increased per capita GDP (GDP) (Othman, 2010). Supply of fish from domestic suppliers may not raise the expected amount for consumption. Therefore, both fish imports and fish prices are expected to increase.

Aquaculture in Malaysia has been one of the top 15 producers in the world, with a cumulative output of 521,000 tonnes (FAO, 2016). As a global producer of fisheries sector, it is important to ascertain the framework and the current challenges faced by the business. In 2013, the fisheries sector contributed 1.1% of the world's production, with contribution of 0.4% in aquaculture (Chan, 2017). Aquaculture contributes 8.9 per cent of the overall national gross domestic product (GDP), supplying Malaysians with an unprecedented 1,753,900 million jobs (Fathi, 2018). It shows that the sector offers national food security and acts as the potential contributor in alleviating hunger and poverty around the world (Allison, 2011).

Fish breeding is one of the key areas in the fisheries sector. It is a complex process that involves careful preparation and monitoring procedure. The most essential aspect in fish breeding is to maintain optimum egg quality. A systematic standard egg selection procedure has yet to be implemented in which egg suppliers capture the image of eggs and manually count the quantity of egg production. For manual counting process, the fish egg was counted manually one by one. Since counting the number of fish by hand is difficult and also the possibility of error is high, a system based on the image processing in different places and conditions was designed (Zion et al., 2006).

Recent years, many techniques for automated counting system using image processing with varies domain are proposed, but it is lack of in fish egg domain field. During the process of preparing this project, we only found the latest study in fish egg domain proposed by (Huang et.al, 2016; Westling, et.al, 2014). The method used for the counting process, also varies from each other. Blob analysis, connected components analysis, statistical area measurements, Otsu's method and watershed method are widely applied in the previous research for counting process (Fabic et. al, 2013; Xiaomin and Feihong, 2013).

Counting of fish egg is important especially in hatchery due to the production of eggs in a fish population is a fundamental parameter in fisheries management and quality control (Far Eastern Agriculture, 2016). In view of the aforementioned facts, to automate the counting process using image processing technique would reduce the time consumption, minimize the exposure to unhealthy situation and ensure accurate estimation of fish eggs. The above literatures showed that little research was done for fish egg management in fisheries industry based on quantity and quality especially in Malaysia.

In this study, an automated fish egg counting system is proposed using image processing algorithm in MATLAB software. The method consist three main steps; fish egg image acquisition, image segmentation and counting process. First, a digital camera is used to capture the colour image of fish egg samples. Next, removed all the unwanted background and remaining the region of interest (ROI) in grey images form. Lastly, to isolate overlapping eggs so that accurate counting process can be conducted.

Hence, this project is implemented to ease the fish breeders in terms of counting a total number of fish eggs automatically by capturing the fish images only.

II METHODOLOGY

The study's approach followed the methodology which are detailed as follows.

A. Image Acquisition

Image acquisition is the creation of a digitally encoded representation of the visual characteristics of an object, such as a physical scene or the interior structure of an object (Tambouli, 2020). This process is important to capture a clear and sharp image. For this process, a valuable input must be included where the image captured needs to be clear and sharp in order for MATLAB application to identify the shape of an image. A digital camera with the following specifications is used to digitize the fish egg: Sony α6000 with 16mm-50 mm lens, 4000X4000 image size for optimum detection of fish eggs, and camera flash is turned off. The total images captured are 22 images with different number of fish eggs. Figure 2 provides the examples of fish eggs. The image height of the camera and basin, containing fish eggs, vary from 0.75 meter up to 1 meter depending on the amount and condition of fish eggs. A basin with black colour as shown in Figure 1 is used for convenient image acquisition.

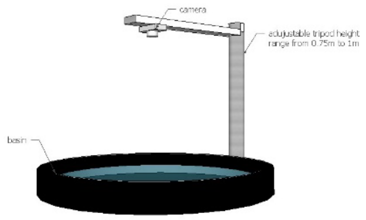

Figure 1. Apparatus setting for image acquisition process

The process of capturing the fish egg image is supposed to be done by the same person in order to avoid any misconduct of the setting. After all the fish egg images have been captured, the images that are clear and sharp are uploaded to MATLAB application to proceed to the next step. Figure 2 shows several samples of the images.

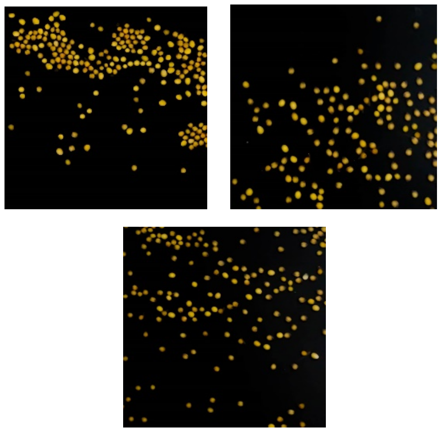

Figure 2. The sample image of fish egg

B. Image Processing

The next process of the system is image in which it determines how the image is processed in order to count the total fish egg images. In this process, there are two sub-processes that need to undergo before the counting process, which are image segmentation and morphological operation.

Image Segmentation (k-means algorithm). Image segmentation is the division of an image into various categories. It divides an image into a number of discrete regions, so that the pixels in each region have high similarity and high contrast between regions. There are several methods that are often used by researchers in image segmentation such as thresholding based, edge based and clustering based. In the process of image segmentation, *k*-means clustering algorithm will be applied in order to choose which image suits more to proceed to counting process. *k*-means clustering algorithm is an unsupervised algorithm and it is used to segment the interest area from the background. The algorithm partitions the given data into *k*-clusters or parts based on the *k*-centroids. In this process the *k* in the k-means algorithm will be determined and set into $k=4$. Figure 3 shows the resulted image on every *k* cluster and $k=4$ is chosen as the most suitable image to be counted in the next process. After the *k* have been set, the image will undergo erosion and dilation process (morphological operation).

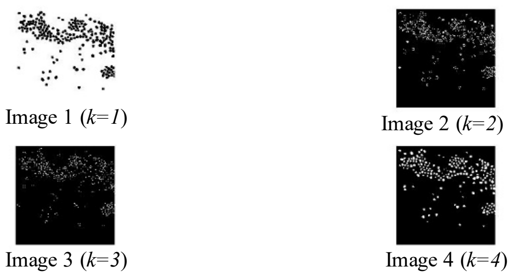

Figure 3. The resulted image of *k*-means algorithm

Morphological Operation. Morphological operations apply a structuring element to an image input, thus creating an image output of the same size. The values for each pixel in the output image are based on a comparison of the corresponding pixel in the input image to its neighbours in a morphological process. There are two process in morphological operation that are being used in this process which are erosion and dilation.

Erosion. Morphological erosion removes islands and small objects so that only substantive objects remain. In this process, erosion is applied in order to reduce boundaries and increase the size of space between each of the eggs so the eggs will not be overlapped. Figure 4 shows the resulted image after being eroded.

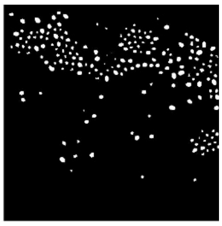

Figure 4. The resulted image when erosion is applied

Dilation. Morphological dilation makes objects more visible and fills in small holes in objects. This process is applied in the system in order to add more pixels in each of the eggs to make it clearer and visible so that the counting process would be easier. Figure 5 shows the resulted image after being dilated.

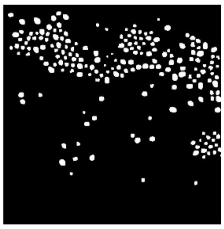

Figure 5. The resulted image when dilation is applied

C. Counting Process

The final step in automated counting system for fish egg is the counting process. In this process, the counting is performed using *bwconncomp* function in MATLAB. This function is used to return the connected components (CC) found in the binary image of fish egg (BW) in order to analyze the wanted region to be counted.

The counting process requires an adequate output for image segmentation or else the counting process is inaccurate. Figure 6 shows the process of the system.

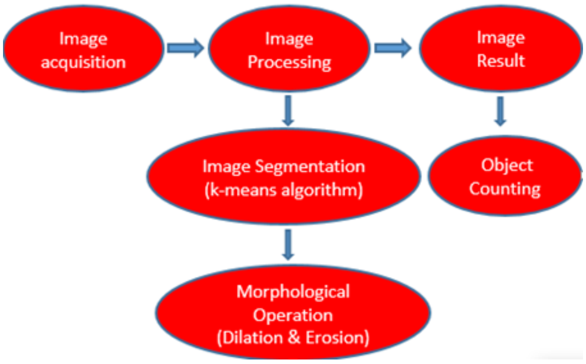

Figure 6. Counting process of fish egg by using image processing method

III DESIGN AND DEVELOPMENT OF AUTOMATED COUNTING SYSTEM FOR FISH EGG (ACSFE)

This section illustrates the design and the development of ACSFE from uploading the fish egg image until counting the total number of fish eggs based on the images.

The design of the system does not have any security features (Sign in, Register) because it allows anyone to have access to the system. The security features might be developed for future updates.

As the user opens the system, it will be directed to the main page where the user can fill in the details of the fish egg (Name of fish, venue) and upload the image. This page includes several functions such as ‘Upload image’ button, ‘Count’ button, ‘Save’ button, and ‘Reset’ button as shown in Figure 7.

Table 1. Main Page Requirement

No.	Requirement ID	Requirement Description	Priority
	ADF_03	**Manage image (data)**	
5	ADF_03_01	User able to upload image	M
6	ADF_03_02	User able to run image	M
7	ADF_03_03	User able to save image	M
8	ADF_03_04	User able to reset image	M

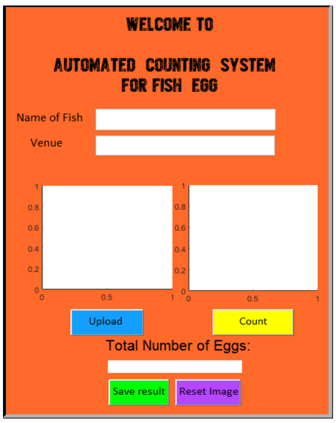

Figure 7. Main page of ACSFE

The user could fill in the detail of the fish egg and upload the image by clicking on the 'Upload' button, followed by the 'Count' button to count the number of fish eggs as shown in Figure 8. The result will be displayed in the textbox given as well as the image of the fish egg that have been converted into binary image (black &white).

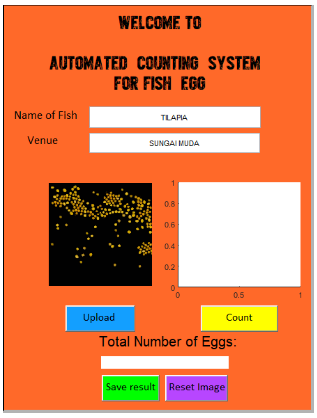

Figure 8. Upload image

After the user finished uploading the image, the result can be counted by clicking the 'Count' button. A binary image will be produced as well as the total number of fish eggs in the space provided as shown in Figure 9.

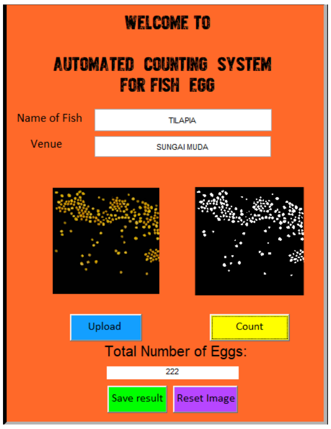

Figure 9. Counting image

After completing all the processes, the user could click 'Save' button to save the image counted with the result or the user can click on 'Reset' button to enter a new image and all the images will be reset.

IV RESULTS OF AUTOMATED COUNTING SYSTEM FOR FISH EGG (ACSFE)

A. System Result

For the system result, the automated counting process has been analyzed by doing comparison to manual counting process. All 22 images were counted and the average duration recorded by using the Eq. (1) below:

$$t_{avg} = \frac{\sum_{i=1}^{n} t_i}{n} \qquad (1)$$

where t_i and n represent the counting time for i-th image and total samples, respectively. Table 2 shows the result of the manual counting process.

Table 2. Result of Manual Counting Process of Fish Egg

Image No.	No of eggs count	Counting Time, t (sec)
1	214	277.0
2	132	145.0
3	142	153.0
4	159	224.0
5	162	273.0
6	194	152.0
7	159	203.0
8	156	212.0
9	158	238.0
10	160	251.0
11	260	274.0
12	73	57.0
13	169	198.0
14	259	183.0
15	104	119.0
16	328	287.0
17	170	154.0
18	110	100.0
19	263	234.0
20	169	150.0
21	169	136.0
22	205	194.0
Average duration (t_{avg})		191.54

Based on the data collected for the manual counting process, the time taken for the manual counting process are considered as long by averaging time of 03:19 minutes for all 22 image sample.

Table 3 below shows the result of automated counting of fish egg for 22 images.

Table 3. Result for Automated Counting

Image No.	Manual counting	Automated Counting	Accuracy (%)	Counting Time, t (sec)
1	214	202	94.39	1.71
2	132	132	100	1.14

Image No.	Manual counting	Automated Counting	Accuracy (%)	Counting Time, t (sec)
3	142	145	97.93	1.52
4	159	157	98.74	1.19
5	162	145	89.51	1.22
6	194	189	97.42	1.32
7	159	153	96.22	1.12
8	156	117	75	1.25
9	158	116	73.42	1.40
10	160	154	96.25	1.23
11	260	229	88.07	1.34
12	73	68	93.15	1.05

Image No.	Manual counting	Automated Counting	Accuracy (%)	Counting Time, t (sec)
13	169	168	99.41	1.21
14	259	233	89.96	1.45
15	104	104	100	1.10
16	328	302	92.07	1.53
17	170	164	96.47	1.21
18	110	102	92.72	1.15
19	263	216	82.13	1.33
20	169	141	83.43	1.20
21	169	165	97.63	1.25
22	205	193	94.15	1.30

Based on Table 3, the time to process the image for the automatic counting process is faster compared to the manual counting process by an average of 1.282727 seconds for all 22 sample images. The gap between automatic and manual counting is very wide for this project, and it can be assumed that the automated counting method is faster compared to the manual counting process for fish eggs, because the average accuracy of this project can also be as high as 99.41%.

B. Evaluation Result

To test the usefulness of the system, a usability evaluation has been conducted comprising 10 respondents selected among the postgraduate students and lecturers at one of the public university in the northern of Malaysia, with expertise and experience in image processing area.

The instruments used for the evaluation were the ACSFE system and a post-task questionnaire. The post task questionnaire was prepared using online Google Form, which consists of two sections. Section A consists of demographic questions while Section B contains questions related to respondents' opinions on the usability of ACSFE in a five-point Likert scale where one represents strongly disagree, and five represents strongly agree. The respondents followed the step-by-step procedure before answering the evaluation. The steps are as follows:

1) Read the information sheet and sign the consent form

2) Interact with the function of ACSFE based on the information sheet

3) Answer the post-task questionnaire

As for the demographic information, 70% of the respondents are Image Processing Experts, while 30% are Academia Researchers. Most of the respondents are male 70% of the total respondents, while 30% of the respondents are female. The age group of the respondents are 10%, 30%, 40% and 20% with age being classified into 21-25, 26-35, 36-45, and above 46, respectively. Most of the respondents (i.e. 70%) did not know about any system that can automatically count fish eggs while another 30% are not sure with the statement.

Section B of ACSFE measures the respondents' perception towards ACSFE usefulness and ease of use. It also measured the respondents' satisfaction towards ACSFE. Tables 4, 5, and 6 reported the frequency and average of the responses. The respondents rated at least "Agree" to the three aspects of the usability. None of the respondents disagreed with only a few rated as "Neutral".

Table 4. The Respondents' Responses on the Usefulness of ACSFE

Post task questionnaire item	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Average
ACSFE enhances my effectiveness on calculating the amount of fish egg	0 (0.00)	0 (0.00)	0 (0.00)	1 (10.00)	9 (90.00)	4.9
ACSFE increases my productivity	0 (0.00)	0 (0.00)	0 (0.00)	1 (10.00)	9 (90.00)	4.9
ACSFE makes it easier to the count the fish egg	0 (0.00)	0 (0.00)	0 (0.00)	3 (30.00)	7 (70.00)	4.7
ACSFE gives me greater control over my work	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	10 (100.00)	5
ACSFE enables me to accomplish tasks more quickly	0 (0.00)	0 (0.00)	0 (0.00)	1 (10.00)	9 (90.00)	4.9

ACSFE saves me time when I use it	0 (0.00)	0 (0.00)	0 (0.00)	4 (40.00)	6 (60.00)	4.6
ACSFE meets my needs.	0 (0.00)	0 (0.00)	0 (0.00)	3 (30.00)	7 (70.00)	4.7
ACSFE does everything I would expect it to do	0 (0.00)	0 (0.00)	0 (0.00)	3 (30.00)	7 (70.00)	4.7
ACSFE is useful in overall.	0 (0.00)	0 (0.00)	0 (0.00)	1 (10.00)	9 (90.00)	4.9

Table 5. The Respondents' Responses on the Ease of Use of ACSFE

Post task questionnaire item	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Average
ACSFE is easy to use	0 (0.00)	0 (0.00)	0 (0.00)	2 (20.00)	8 (80.00)	4.8
ACSFE is user friendly	0 (0.00)	0 (0.00)	0 (0.00)	2 (20.00)	8 (80.00)	4.8
ACSFE is flexible	0 (0.00)	0 (0.00)	0 (0.00)	1 (10.00)	9 (90.00)	4.9
ACSFE required fewer steps to accomplish what I want to do with counting the fish eggs.	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	10 (100.00)	5
ACSFE is easy to learn how to use it.	0 (0.00)	0 (0.00)	0 (0.00)	1 (10.00)	9 (90.00)	4.9
I can use ACSFE without written instructions.	0 (0.00)	0 (0.00)	0 (0.00)	1 (10.00)	9 (90.00)	4.9
I can easily remember how to use it.	0 (0.00)	0 (0.00)	0 (0.00)	1 (10.00)	9 (90.00)	4.9
I do not notice any inconsistencies as I use ACSFE	0 (0.00)	0 (0.00)	0 (0.00)	3 (30.00)	7 (70.00)	4.7
I can recover from mistakes quickly and easily when using ACSFE.	0 (0.00)	0 (0.00)	0 (0.00)	3 (30.00)	7 (70.00)	4.7
I can use ACSFE successfully every time	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	10 (100.00)	5

Table 6. The Respondents' Responses on the Satisfaction of ACSFE

Post task questionnaire item	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Average
I am satisfied with ACSFE.	0 (0.00)	0 (0.00)	0 (0.00)	2 (20.00)	8 (80.00)	4.8
I would recommend ACSFE to my friend.	0 (0.00)	0 (0.00)	0 (0.00)	3 (30.00)	7 (70.00)	4.7
ACSFE works the way I want it to work.	0 (0.00)	0 (0.00)	0 (0.00)	1 (10.00)	9 (90.00)	4.9
I feel I need to have ACSFE.	0 (0.00)	0 (0.00)	4 (40.00)	1 (10.00)	5 (50.00)	4.1
ACSFE is wonderful and pleasant to use.	0 (0.00)	0 (0.00)	0 (0.00)	1 (10.00)	9 (90.00)	4.9

ACSFE was considered to be effective and easy to use based on the results of the evaluation. In addition, the respondents' reported that they were satisfied with the features of the app that facilitate their needs with the system. The respondents also professed that ACSFE could help them in counting the number of fish eggs faster than manual counting and the results also have high accuracy. The respondents indicated that ACSFE was easy to use without the need for written guidance about the user interface, and the respondents can easily remember how to use the system. In addition, the respondents were pleased with the system's functionality, and expected to suggest the system to others.

V CONCLUSION AND FUTURE WORKS

As a conclusion, this paper presents an automated way to count the number of fish eggs by using image processing method which is *k*-means algorithm. This system demonstrates potential to automatically count the number of fish eggs rather than using manual counting that consumes a lot of time. The result of the system also indicates significance with a high accuracy up to 99.41% which is reliable to be used. ACSFE could increase the fishery companies' efficiency by providing exceptionally fast and high average counting accuracy compared to the conventional manual counting process.

Furthermore, this system is simple and user friendly. For future works, the system can be improved in terms of security features where the user can be able to sign in and register to use the system. Besides, for future updates, users who already have an account to the system may experience more features of the system in terms of choosing a good quality of fish egg and also improve the counting process of the fish egg.

Finally, process steps for automatic counting of a total number of fish eggs defined and empirical tested in the research finding would be replicating as a knowledge transfer process for future study in fish eggs domain. Suggestion for future research to design and develops highly accurate system with more contrast fish egg image which builds upon earlier findings of this study.

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