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Full Length Research Paper

Automated Fish Length Measurement via Digital Image Analysis: A Novel Methodology

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Fish is an important source of protein in most countries in the world. The need to know the reproduction and population of fish is crucial for optimum exploitation of fish resources in maintaining the requirement of mankind in the future. In fisheries research, the length of a fish is the main parameter needed to identify fish reproduction, recruitment, growth and mortality. Current method used to acquire these length samples could be problematic as it is manually done; the fish need to be purchased in large quantities and then measuring one by one is time consuming and imprecise. The manual process may lead to overflowing cost. The fish length from digital images (FileDI) framework attempts to avoid this problem using a combination of optical theory and image processing techniques that automatically measures the length of the fish. It reduces cost, faster than previous method and yields accurate length measurement. Preliminary test has shown that the confident level of the FiLeDI framework accuracy is as high as 95% for fish length measurement.

Key words: Fish length, image processing, optical theory.

INTRODUCTION

In fisheries research, the length of a fish is an important parameter in determining fish population, mortality, growth, reproduction and recruitment which in turn, can help in the assessment of fish stock. During the period of fish reproduction, even if fishing activity is increased, the revenue would be significantly less (Figure 1) (Sparer and Siebren, 1998). Thus, knowing the period of fish reproduction is essential to identify the amount of stock available so that fisheries sector can maximize revenue and maintain nationwide fish stock.

However, information of fish length is very limited as it is currently obtained manually (Norhaida et al., 2009). This means that the fish is measured one by one using a measuring tool. Needless to say, it is time consuming especially when the number of fish to be measured increases. Moreover, this manual process requires the researchers to purchase the fishes from fishermen, adding to huge amount of cost. Therefore, an easy, fast and cost-effective approach is needed to solve this problem (Haron et al., 2011).

The fish length from digital images (FiLeDI) framework, is a method of measuring fish length from a digital image proposed in this paper where several matters are first observed. First is the issue of how to acquire the image itself; second is how to process the image to obtain the ‘image size’ of the fish, and third is how to calculate ‘actual size’ of the fish from pixel value. These are the issues addressed in this research. This framework uses optical theory and image processing techniques to obtain the actual fish length from the image. In this paper, detailed discussion of the FiLeDI framework, its imple- mentation, testing and evaluation are presented.

PREVIOUS WORK

Research work has been done previously for various applications and location using stereo vision system

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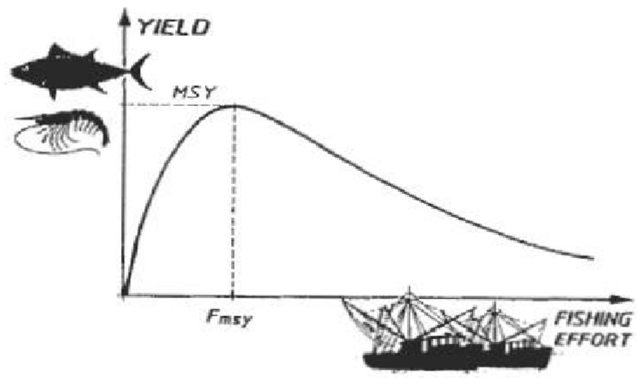


Figure 1. Fish stock assessment.

Figure 2. Fish length measurement using measurement tape.

(Naiberg, 1994), stereo video camera system (Harvey, 2003), stereo photographic (Jules, 1996), a dual underwater camera (Costa et al., 2006) and simple video techniques (Petrell, 1997). The main point in these techniques is that, the fish are measured underwater. By measuring underwater, fish growth could be monitored, mortality and stress due to fish sampling could be reduced, and divers' intervention could be limited (Costa et al., 2006). These techniques are also used to determine the feed and medication, and to decide when to gather the yields of fish (Naiberg, 1994), yet, these approaches (Naiberg, 1994; Harvey, 2003; Jules, 1996; Petrell, 1997) can cause stress to the fish as the underwater equipment used can disturb their ecosystem.

Several other methods solve this issue by obtaining fish sampling from fisherman yields. The sampling process can be done right as the fishermen return from fishing activities. In these methods, computer vision approach (Yousef and Sultana, 2006; Tasdemir et al., 2008; Elarbi- Boudihir et al., 2011) is applied to obtain the length of the fish. It requires equipment such as conveyor belt, light box, camera, sensor and computer that are expensive and space consuming. Therefore, this approach is suitable for industrial sectors with huge capital; and is mainly used to sort the fish based on species, size and weight. However, in developing countries, the use of computer vision technology is still unaffordable because of the high investment required to prepare the equipment. Figure 2 shows the current method used instead, which require a measurement tape to manually measure the fish.

In recent years, numerous researches have been done to calculate size of object in a digital image. Some method use reference object to guide the calculation of the objects' actual size, while some used optical theory. The former method has been implemented in geographic information system (GIS), medical imaging and computer graphics. For example, Pickle (2008) developed software titled analyzing digital images that uses a reference object such as a ruler to obtain the object of interests' actual size. The advantage of Pickle's method is that the image can be measured without parameters such as fix distance and illumination, but even so, when capturing an image, a reference object will always be needed.

Jules (1996) proposed a solution which can directly obtain the actual size of the object from digital image without the need of using any reference object. It opens opportunities for fishery researchers to perform data sampling much faster. Besides, it does not need a lot of equipment which also makes it a lot more cost effective. Although that, Jules (1996) approach still need improvement as it does not detect object in an image automatically. Besides that, very simple features are extracted whilst fish has complex and curvy features, especially its head and tail. Therefore, to obtain its accurate size, each edge of the fish must be precisely detected.

From previous work, a lot of techniques to detect object like fish in image automatically such as object recognition (Naiberg, 1994), contour extraction (Costa et al., 2006), chain code (White et al., 2006), filtering (Lee et al., 2004) and corner detection (Kiranyaz et al., 2007). Corner detection were implied by maximizing bending ratio and curvature, which makes it more accurate in detecting corners of an object and in this case, it could be suitably applied to detecting fish in a digital image (Kiranyaz et al., 2007). We develop a new method to measure FiLeDI by combining both Hsiu's and Serkan's method. We call this framework "FiLeDI" where in this paper its framework will be discussed.

Fish length from digital images (FiLeDI) framework

FiLeDI stands for fish length from digital image measurement framework. It is more economical than previous approach and also faster in sampling data. FileDI framework takes advantage of the optical theory introduced in Hsiu (2008) method and combining it with image processing techniques to measure fish length for data sampling process (Norhaida et al., 2009). Firstly, optical theory is used to formulate equation in order to obtain the value of image scaling. Next, image pro- cessing techniques are used to obtain fish length in pixel value. Subsequently, the fish length in pixel value will be processed with the scale value obtained from the optical theory to determine the actual size of the fish length. In this proposed FileDI framework, enhancement has been done to improve Hsiu (2008) and Kiranyaz et al. (2007) method in obtaining the scale value and corner detection, respectively. Figure 3 shows the processes involved in FileDI framework.

DATA

Data used as input in FiLeDI framework are:

1) Fish images
2) Focus length (*f*)
3) Distance object (*O*)
4) Pixel size (mm)

The data required in this framework are already contained in the image properties of the digital images and can be extracted by the FileDI framework system. Fish images must be in digital format; in the testing result presented in this paper, bitmap (*.bmp) file was used. Focus length (*f*) and object distance (*O*) are used to identify scale value, while pixel size is used to calculate fish length in pixel unit.

Pre-processing

Pre-processing is done to the image input to detect the head and tail of fish. It is first carried out in order to locate one-pixel thin object boundaries. This process consists of three major parts. Firstly is iterative bilateral filtering and canny edge detection to form the scale-map. Secondly, sub-segment formation and analysis. Finally, the selection of the relevant sub-segments using a relevance model. The object(s) can be extracted after the required numbers of relevant sub-segments are selected and the corner detector proceeds over the object boundary (CL segment) or alternatively it can proceed over the NCL sub-segments, one at a time. More detail on this pre-processing phase can be found in Ferreira et al. (2006).

Bending ratio plot

The next process is to calculate bending ratio plot. The formula of the bending ratio can be expressed as follows:

$$BR(p_1) = \frac{L_s}{d_\infty(p_1 + p_2)} \qquad (1)$$

Where, L_s is the number of pixel from *P*1 to *P*2 and d_∞ represents the distance in *L*∞ norm. Figure 4 shows BR calculation.

Matthew et al. (2002) checked for true corner during the tracing process, if *BR* (p) *T BR*, where T *BR* ≥ 1 is an empirical threshold, which can be set higher to detect only sharper (with smaller angle) corners in particular. A discrete curvature approximation is used within the moving window to find exact corner location. The curvature function *κ(u)* is the derivative of the orientation function *Ø(u)* shown in Equation 2 (Kiranyaz et al., 2007).

$$\phi(u) = \tan^{-1}\left(\frac{\dot{y}(u)}{\dot{x}(u)}\right) \Rightarrow \kappa(u) = \frac{\dot{x}(u)\ddot{y}(u) - \ddot{x}(u)\dot{y}(u)}{(\dot{x}^2(u) + \dot{y}^2(u))^{3/2}} \qquad (2)$$

The curvature at a given contour pixel from the positions of neighbouring pixels (*p*-1), *p*, and (*p*+1) can be approximated as in Equation 3 (Kiranyaz et al., 2007):

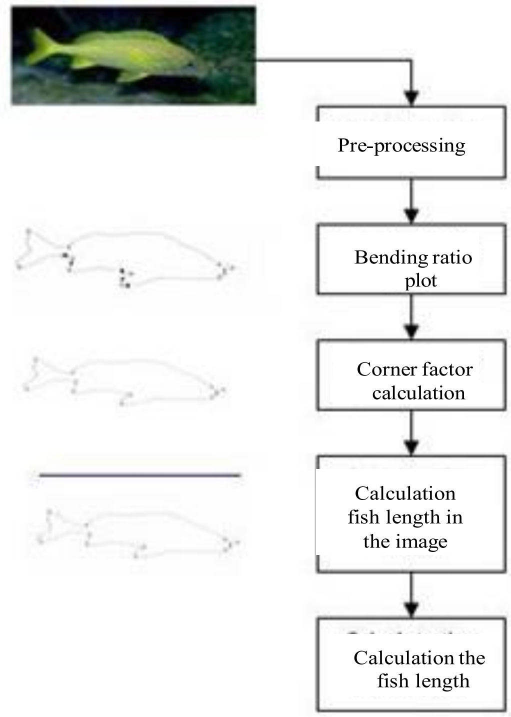


Figure 3. Flow chart of FiLeDI framework.

$$\kappa(p)=\frac{(x_{p+1}-x_{p-1})(y_{p-1}-2y_p+y_{p+1})-(y_{p+1}-y_{p-1})(x_{p-1}-2x_p+x_{p+1})}{((x_{p+1}-x_{p-1})^2+(y_{p+1}-y_{p-1})^2)^{3/2}} \quad (3)$$

Basically in Equation 1, all the (potential) corners yielding a peak in BRP are detected.

Corner factor calculation

In this step, corner factor is used to obtain the actual value of the corners of a fish. Let $CF(p^i c)$ be the corner factor of the ith potential corner, $p^i c$ and can be expressed as follows:

$$CF(p^i c) = BR(p^i c) \times k(p^i c) \quad (4)$$

This will give a result of two points, representing the head and the tail of the fish.

Calculate fish length in the image

The head and tail pixel points obtained from the previous step is next used to calculate the image size of the fish by multiplying the number of pixels with pixel size as shown in Equation 5. a1 = a2 ==> tag a1 = tag a2

Fish length in image (*fl*) = (Number of pixels) x (Pixel size) (5)

Calculate the fish length

The final step in this framework is to obtain the actual length of fish. For that, we must multiply the value of fish length in image (*fl*) with ratio value.

Actual fish length = *fl* x (*O/f*) (6)

Equation 6 is obtained from optic theory (Figure 7). There are four important variables:

1) The size of the object (Y1)
2) The distance of the object from the lens (X1)
3) The size of the image on the sensor or the film (Y2)
4) The distance between the sensor and the lens (X2)

Referring to Figure 5, two right triangles can be found. Several rules concerning triangles are used in this framework (Figure 6).

Tangent is an opposite side or adjacent

Tag a1 = Y1/X1 (7)

Tag a2 = Y2/X2 (8)

Tag a1 = tag a2 ==> Y1/X1 = Y2/X2 ==> we can inverse both sides of the equation

X1/Y1 = X2/Y2 (9)

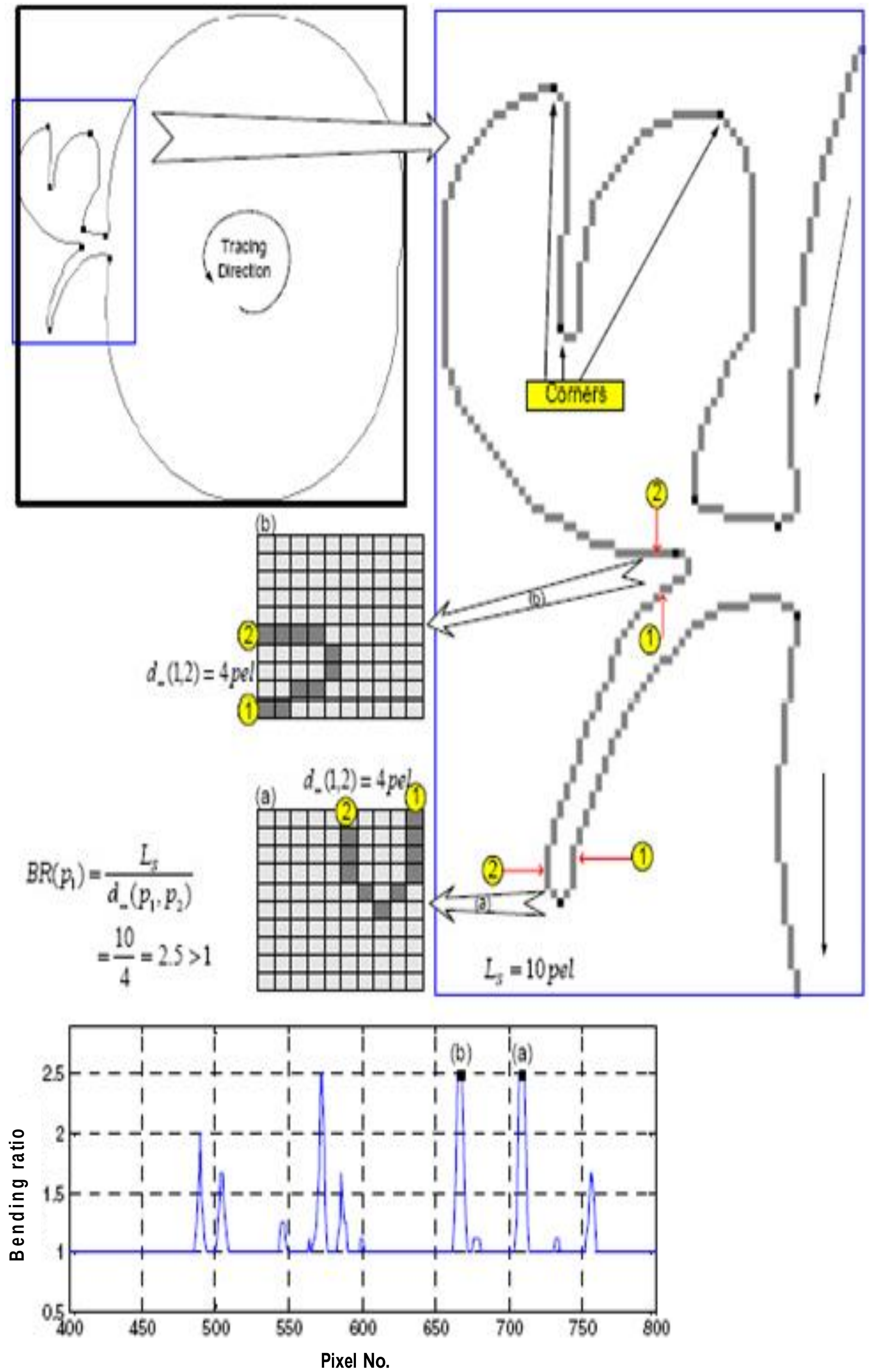


Figure 4. (a) BR calculation on a sample shape for two corner; (b) detected (Kiranyaz et al., 2007).

The variable name of Y1 is a size of object, which in FileDI framework represents the fish length. However, this framework requires three variables, Y2, X2 and X1 to obtain the fish length. The variable Y2 is the size of the image on the sensor or the film, which in this framework represents the length of fish image (*fl*). Variable X2 re- fers to focal length (*f*), while X1 refers to mean object distance (*O*).

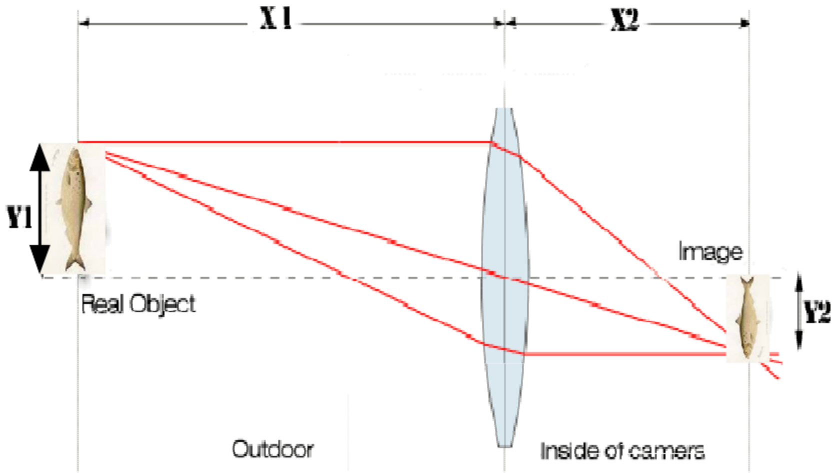


Figure 5. A simple imaging system.

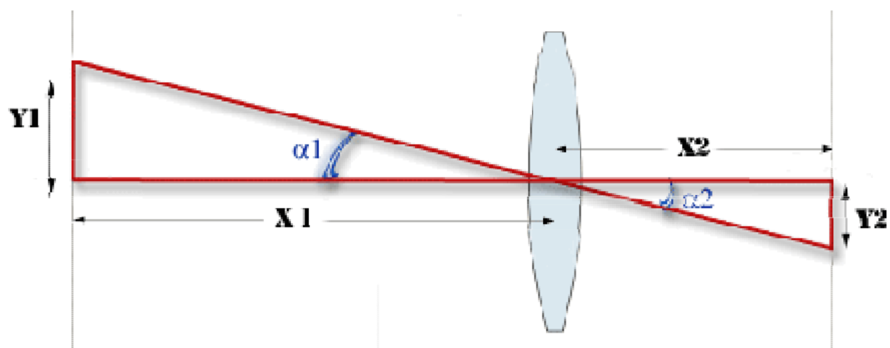


Figure 6. Geometry concept.

Testing and evaluation

To evaluate the implementation result of the FileDI framework, two types of species were chosen with different sizes. There are twenty fishes each from the species *Selar crumenophthalmus* and *Rastrelliger kanagurta*. Images were taken with different types of camera and illumination. The comparisons with position of camera were tested only with *S. crumenophthalmus*. Figure 7 shows the process to measure fish length using FiLeDI framework for testing the *S. crumenophthalmus*.

RESULTS

The results were divided into three conditions; camera types, illumination and camera position, to determine which of these conditions influence the accuracy of the fish measurement (Figure 8).

Camera

Table 1 and Figure 10 show the measurement result of the *S. crumenophthalmus*. Pentax camera (8.0 megapixel) has shown a better result with 0.74% error, compared to Sony (5.0 megapixel) with 2.19% error. In this case, the manual method (manually measuring the fish using measuring tape) acts as a true value. Meanwhile, Table 2 and Figure 9 show the testing result of *R. kanagurta*. Sony camera recorded a result closed to the true value with 1.81% error while Pentax recorded a 2.85% error.

Illumination

Tables 3 and 4, and Figures 10 and 11 show the comparison result of using Pentax camera with and without flash.

For *S. crumenophthalmus* (Figure 10), the result with flash recorded a 0.74% error compared to 6.03% error without flash. Meanwhile, the result for *R. kanagurta* (Figure 11) recorded a 2.85% error with flash compared to 3.68% error without flash.

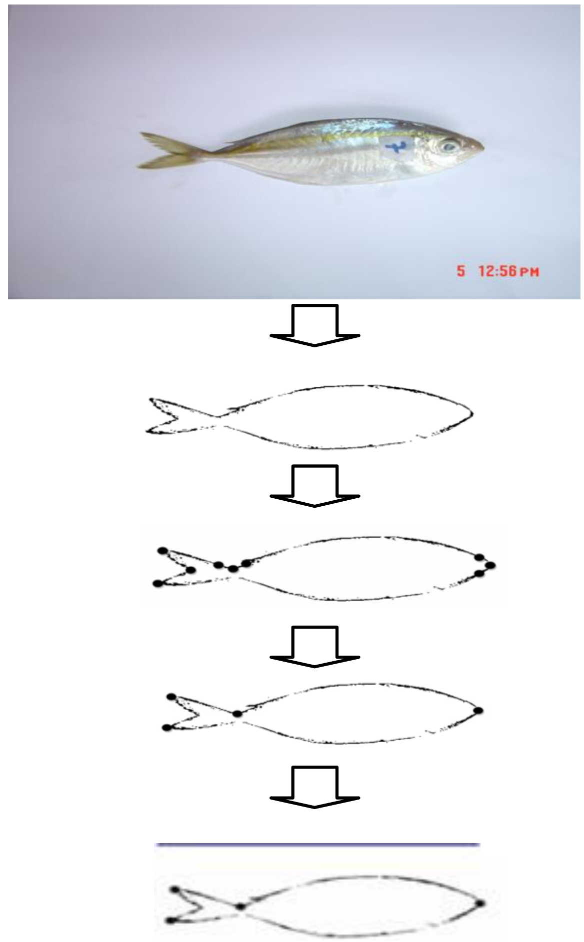


Figure 7. The process to measure fish length using FiLeDI framework.

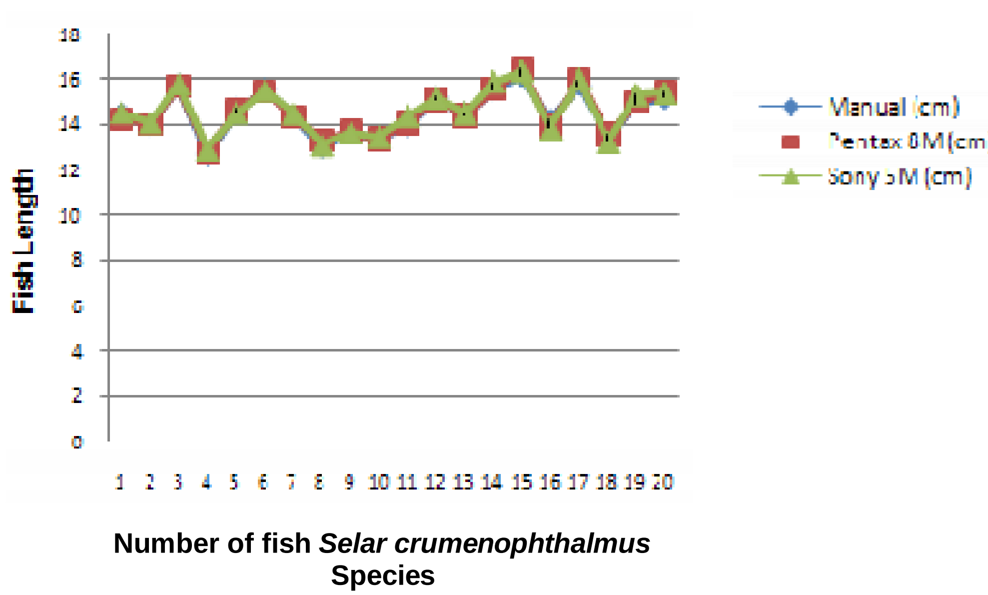


Figure 8. The comparison with different types of camera for *S. crumenophthalmus*.

Table 1. Result of comparison with different types of camera for *S. crumenophthalmus*.

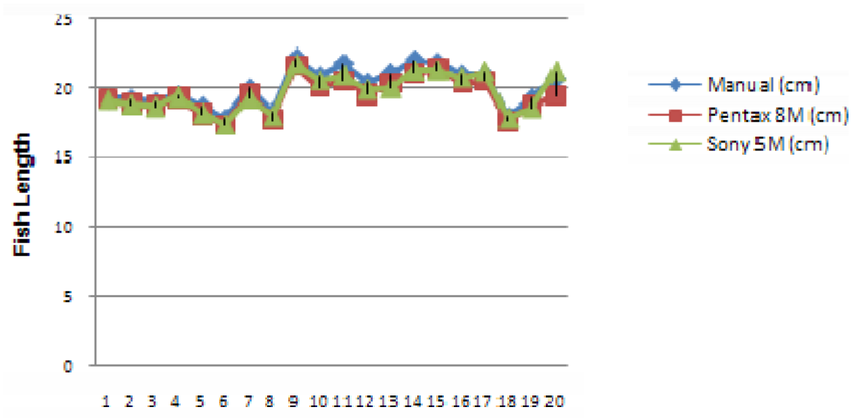
Number	Manual (cm)	Pentax 8M (cm)	Sony 5M (cm)
1	14.5	14.27	14.57
2	14.0	14.04	14.14
3	15.8	15.73	15.83
4	12.7	12.85	12.95
5	14.7	14.63	14.55
6	15.6	15.51	15.56
7	14.4	14.35	14.54
8	13.0	13.33	13.15
9	13.7	13.72	13.67
10	13.4	13.38	13.50
11	14.0	14.10	14.42
12	15.2	15.15	15.22
13	14.5	14.43	14.54
14	15.6	15.59	15.91
15	16.2	16.50	16.40
16	14.2	13.95	13.86
17	15.8	16.00	16.01
18	13.5	13.60	13.28
19	15.0	14.97	15.35
20	15.2	15.46	15.43

Table 2. Result of comparison with different types of camera for *R. kanagurta*.

Number	Manual (cm)	Pentax 8M (cm)	Sony 5M (cm)
1	19.2	19.20	19.20
2	19.2	18.85	18.87
3	19.0	18.77	18.68
4	19.5	19.30	19.41
5	18.7	18.17	18.24
6	17.8	17.38	17.43
7	20.0	19.59	19.28
8	18.3	17.77	18.07
9	22.2	21.65	21.75
10	20.9	20.06	20.58
11	21.8	20.57	20.95
12	20.4	19.58	19.94
13	21.1	20.34	20.03
14	22.1	21.11	21.28
15	21.9	21.45	21.32
16	21.0	20.33	20.77
17	21.0	20.57	21.22
18	18.0	17.66	17.93
19	19.3	18.77	18.64
20	20.7	19.48	21.24

Position of camera

Figure 12 shows the comparison result of using different camera positions illustrated in Figure 13. In this testing, three position angles, 90°, 45°and 135°were used. From the testing outcome, the position of 90° produced the



Number of fish *Rastrelliger kanagurta* Species

Figure 9. The comparison with different types of camera for *R. Kanagurta*.

Table 3. Result of comparison with different types of illumination for *S. crumenophthalmus.*

Number	Manual (cm)	Without flash (cm)	Flash (cm)
1	14.5	13.50	14.27
2	14.0	13.14	14.04
3	15.8	14.78	15.73
4	12.7	11.97	12.85
5	14.7	13.90	14.63
6	15.6	14.52	15.51
7	14.4	13.45	14.35
8	13.0	12.58	13.33
9	13.7	12.79	13.72
10	13.4	12.66	13.38
11	14.0	13.28	14.10
12	15.2	14.21	15.15
13	14.5	13.61	14.43
14	15.6	14.49	15.59
15	16.2	15.56	16.50
16	14.2	13.07	13.95
17	15.8	14.93	16.00
18	13.5	12.68	13.6
19	15.0	14.03	14.97
20	15.2	14.31	15.46

closest result to the true value. Results comparisons are presented in Table 5.

ANALYSIS AND DISCUSSION

Based on the preliminary testing done and the results shown, the FiLeDI framework gave a good accuracy result when *S. crumenophthalmus* was tested using Pentax Optio E40 (8 megapixel) with flash. For *R. Kanagurta*, the result shows that Sony is better than Pentax when in fact, the result produced by Pentax is supposed to be more accurate since its resolution is higher than Sony. This inaccuracy result occurred due to blurred pictures taken when testing *R. Kanagurta* using Pentax camera. Therefore, it can be concluded that the

Table 4. Result of comparison with different types of illumination for *R. kanagurta*.

Number	Manual (cm)	Without flash (cm)	Flash (cm)
1	19.2	18.98	19.20
2	19.2	18.47	18.87
3	19.0	18.11	18.68
4	19.5	18.52	19.41
5	18.7	17.82	18.24
6	17.8	16.89	17.43
7	20.0	18.96	19.28
8	18.3	17.28	18.07
9	22.2	21.17	21.75
10	20.9	20.17	20.58
11	21.8	21.13	20.95
12	20.4	19.73	19.94
13	21.1	21.05	20.03
14	22.1	20.79	21.28
15	21.9	21.29	21.32
16	21.0	20.41	20.77
17	21.0	20.37	21.22
18	18.0	17.69	17.93
19	19.3	18.28	18.64
20	20.7	20.18	21.24

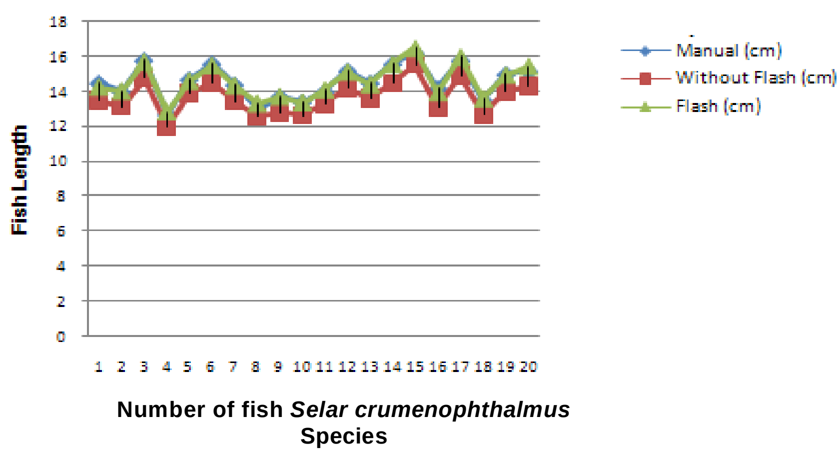


Figure 10. The Comparison with different of Illumination for *S. crumenophthalmus*.

acquisition of a good quality image is important before the image is processed. From the results, it can also be concluded that the images should be taken with flash, and that illumination is another important element in image acquisition step.

The testing also includes comparison of different Camera positions where it is shown that the best position is 90˚ (Misimi, 2007). In Tables 1 and 2, the results show that whenthesizeof fishincreases, theerroralso increases.

This study demonstrates that FiLeDI framework could be used in measuring the length of a fish; and also that there are still rooms for improvement. Hence, the next step to enhance this framework will focus on how to detect edge accurately to further obtain better accuracy in measuring fish length. Region-Based (Saba et al., 2010; Kurniawan et. al. 2011, Rahim et al., 2012) could be one of the methods used to obtain better accuracy as threshold value of the images could be identified by the

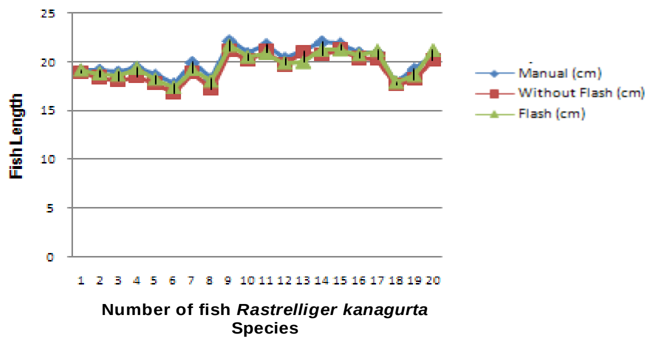


Figure 11. The comparison with different of illumination for *R. kanagurta*.

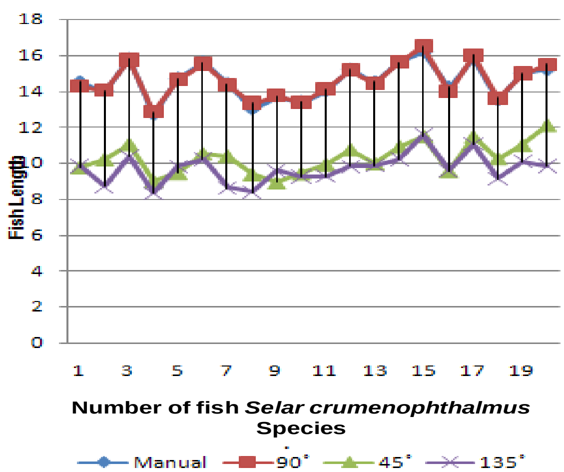


Figure 12. The comparison with position of camera for *S. crumenophthalmus*.

normalization process.

CONCLUSION

This research is expected to contribute an automated method of measuring the length of a fish using optical theory and image processing techniques. This method has high potential to be commercialized given its high reliability, durability and accuracy factors as well as minimizing cost and time needed for such task. This means that, it is able to measure the length of a fish without having a person holding the fish. The idea is to capture the image of the fish using a digital camera, and then processed into the FiLeDI framework software to automatically determine the actual length of the fish (Norhaida et al., 2009; Rahim et al., 2011). In fisheries sector, the impact of the contribution from this research ensures the stability and security of the country's main source of protein.

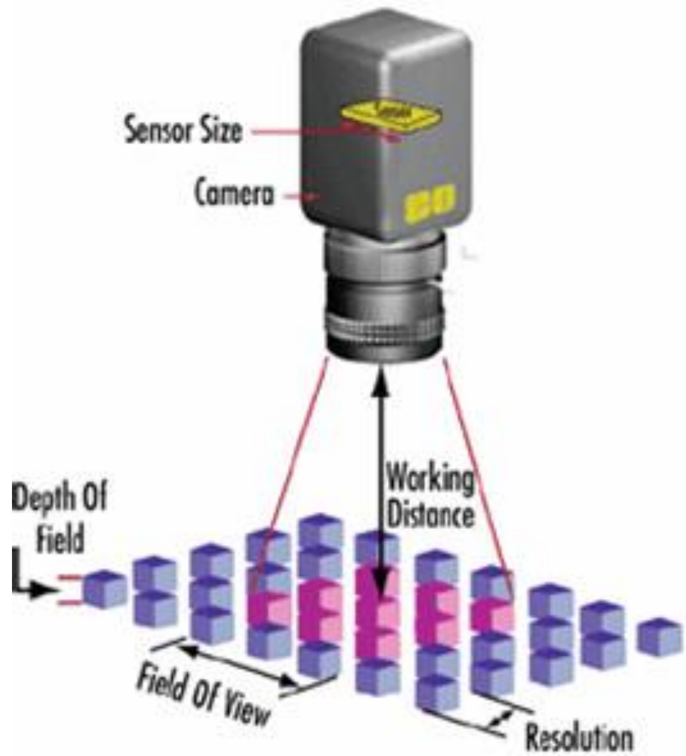


Figure 13. Definition of the most important parameters of camera optics (Courtesy of Edmund Optics) (Naiberg, 1994).

Table 5. Result of comparison with position of camera for S. crumenophthalmus.

Number	Manual	90˚	45˚	135˚
1	14.5	14.27	9.74	9.81
2	14.0	14.04	10.18	8.68
3	15.8	15.73	11.04	10.35
4	12.7	12.85	8.97	8.30
5	14.7	14.63	9.42	9.78
6	15.6	15.51	10.52	10.19
7	14.4	14.35	10.37	8.58
8	13.0	13.33	9.37	8.35
9	13.7	13.72	8.91	9.58
10	13.4	13.38	9.41	9.21
11	14.0	14.10	9.91	9.24
12	15.2	15.15	10.74	9.80
13	14.5	14.43	9.96	9.84
14	15.6	15.59	10.89	10.20
15	16.2	16.50	11.46	11.56
16	14.2	13.95	9.53	9.56
17	15.8	16.00	11.45	11.04
18	13.5	13.60	10.23	9.11
19	15.0	14.97	10.99	10.06
20	15.2	15.47	12.08	9.81

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REFERENCES

Costa C, Loy A, Cataudella S, Davis D, Scardi M (2006). Extracting fish size using dual underwater cameras. Aquacult. Eng., pp. 218-227.

Elarbi-Boudihir M, Rehman A, Saba T (2011). Video Motion Perception Using Operation Gabor Filter. Int. J. Phys. Sci., 6(12): 2799-2806.

Ferreira M, Kiranyaz S, Gabbouj M (2006). A novel shape descriptor over multi-scale edge field: 2D Walking Ant Histogram. Proc. of IWSSIP, Budapest, Hungary, pp. 475-378.

Haron H, Rehman A, Wulandhari LA, Saba T (2011). Improved vertex chain code algorithm for curve length estimation" J. Computer Sci., 7(5): 736-743. DOI: 10.3844/jcssp.2011.736.743

Harvey E (2003). The accuracy and precision of underwater measurement of length and maximum body depth of southern bluefin tuna (*Tunnus maccoyii*) with a stereo-video camera system" Elsevier, Fisheries. Res., 63: 315-326.

Hsiu HO (2008). Method for calculating distance and actual size of shot object. United States Patent.

Jules M (1996). A simple field method for stereo-photographic length measurement of free-swimming fish: merits and constraints. J. Exper. Marine Biol. Ecol., 195: 237-249.

Kiranyaz S, Hantao L, Ferreira M, Gabbouj M (2007). An efficient approach for boundary based corner detection by maximizing bending ratio and curvature. Proceedings of 9th International Symposium on Signal Processing and its Applications, ISSPA Sharjah, UAE, pp. 1-4.

Kurniawan F, Rahim MSM, Daman D, Rehman A, Muhammad D, Shamsudin SM (2011). Region-Based Touched Character Segmentation in Handwritten Words, Int. J. Innovative Computing, Info. Control, 7(6): 3107-3120

Lee D, Schoenberger R, Shiozawa D, Xu X, Zhan P (2004). Contour matching for a fish recognition and migration monitoring system. SPIE Optics East, Two and Three-Dimensional Vision System for Inspection, Control Metrol., 5606(5).

Matthew EO, Douglas A. Landis RI (2002). An inexpensive, accurate method for measuring leaf area and defoliation through digital image analysis. J. Econ. Entomol., 95: 1190-1194.

Misimi E (2007). Computer vision for quality grading in fish processing, PhD. Thesis, Norwegian Univer. Sci. Technol., pp. 126-134.

Naiberg A (1994). A unified recognition and stereo vision system for size assessment, MSc. Thesis, University of British Columbia.

Norhaida A, Shafry M, Ismail M (2009). Measuring fish length from digital images (FiLeDI). The 2nd International Conference on Interaction: Science Information Technology, Culture and Human(ICIS), ACM, Seoul, Korea.

Pickle J (2008). Measuring length and area of objects in digital images using analyzing digital images software. Concord Academy.

Petrell R (1997). Determine fish size and swimming speed in cages and tanks using simple video techniques. Elsevier Science, Aquacult. Eng., 16: 63-84.

Rahim MSM, Rehman A, Sholihah N, Kurniawan F, Saba T, Dzulkifli M (2012). Region-based Features Extraction in Ear Biometrics, Int. J. Acad. Res., 4(1).

Rahim MSM, Rehman A, Ab-Jabal MF, Saba T (2011). Close Spanning Tree Approach for Error Detection and Correction for 2D CAD Drawing. Int. J. Acad. Res., 3(4): 525-535.

Saba T, Rehman A, Sulong G (2010). Improved Statistical Features for Cursive Character Recognition, Int. J. Innovative Computing Info. Control, 7(9): 5211-5224.

Sparer C, Siebren B (1998). Introduction to tropical fish stock assessment. FAO Fisher Technical Paper.

Tasdemir S, Abdullah MY, Ürkmez S (2008). Determination of body measurements of a cow by image analysis. International Conference on Computer Systems and Technologies – Comp.Sys.Tech.,*'08*.

White D, Svellingen C, Strachan N (2006). Automated measurement of species and length of fish by computer vision. Fisheries Res., 80: 203-210.

Yousef M, Sultana S (2006). Study on fresh fish sorting techniques. IEEE 3rd International Conference on Mechatronics. pp. 462-467.