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Research paper

Speckle Filtering Method in the Gonad Ultrasound Image for Mahseer's Fish (Tor Tombroides)

Nurul Asmaa Abd Razak [1*], Hizmawati Madzin[2*], Fatimah Khalid [3] and Mas Rina Mustaffa [4]

[1234] Multimedia Department,
Faculty of Computer Science and Information Technology,
Universiti Putra Malaysia
**Corresponding author E-mail: nurulasma_30@yahoo.com,*

Abstract

In fish breeding production, it is crucial to know the maturation of the eggs before spawning. In order to do that, possible use of ultrasound in identifying the eggs in the gonad is investigated. From the previous studies, ultrasound imaging can be affected by speckle noise. Moreover, with the similarity and subtle difference between the speckle noise and mahseer eggs, there is a need to identify the suitable speckle filtering methods in order to find out the eggs in the gonad ultrasound image. Five speckle filtering methods, which are Mean, Median, Wiener, Speckle Reducing Anisotropic Diffusion (SRAD) and Optimized Bayesian Nonlocal Mean (OBNLM) are tested and compared. From the result, it is proven that Median filter is the best speckle filtering method compared to other four filtering method in order to eliminate the speckle noise in the gonad ultrasound image.

Keywords: *Aquaculture; Filtering; Mahseer; Speckle Filtering; Ultrasound*

1. Introduction

Mahseer, Tor tombroides, locally referred to as empurau and kelah, respectively, are highly value sought after fish with an aquaculture potential and of conservational value [1]. The species ranges from Burma, Thailand, Cambodia, Laos and Vietnam throught Peninsular Malaysia to Sumatra, Java and Borneo. In Malaysia, mahseer can be caught in places such as The Royal Belum in Perak, Taman Negara in Pahang and also Andang River in Sarawak. However, these species have suffered severe decline and are now considered threatened due to pollution, habitat loss, and overfishing [2]. These fish are migrating upstream to spawn in smaller streams.

In breeding production, most fish including mahseer reproduce by spawning when the maturation is completed. Spawning is the process releasing the eggs and sperm into the water by the aquatic animals. In order to be spawned, it is very critical to observe the egg's in the gonad during the maturation life cycle to know the quantity of egg's that already matured. There are several procedures that can be used such as via endoscopy [3], gonad histology [4], and ultrasound [5]. Endoscopy can be applied in both medical and veterinary field. This procedure is used to examine the interior of a hollow organ or cavity of the body via insertion of the tool into the body through a small opening or urogenital pore [6]. While, gonad histology is a procedure that provide the details of internal gonad morphology and the process of oogenesis and maturity [4]. However, these two procedures are invasive and life threatening to the fish although it can be used to ascertain the maturity of the egg.

Besides endoscopy and gonad histology, there is one procedure that have the noninvasive method and also can be used to ascertain the maturity of the egg which is ultrasound [7]. To our knowledge, the fish that used the ultrasound imaging for breeding purposes are documented for now are sturgeon ([8]; [9]; [10]; [11]; [12]), bass ([13]; [14]; [15]), salmon [16], catfish ([2]; [17]; [18]), halibut ([19]; [20]), rainbow trout [15], hapuku [21], shark ([22]; [23]), thornback ray [20], haddock [24], cod [25].

However, studies on ultrasound imaging show that this procedure image can be affected by noise such as speckle noise [26]. This speckle noise in medical ultrasound images can lessens the contrast and image resolution in the image, which will affect the accuracy of the result when doing segmentation in image processing later. Therefore, to resolve this problem, speckle filtering method can be used to eliminate the speckle noise in the ultrasound image. Currently, there are many speckle filtering methods such as Median filters ([27]; [28]; [38]), Wiener filter ([29]; [38]) and nonlocal means filter ([30]; [31]; [38]). Nevertheless, these methods are applied to the larger objects rather than applied it to the smaller objects such as fish eggs in the ultrasound image. Besides, the fish egg's size that have subtle difference with the speckle noise make it hard to identify the fish egg's in the gonad ultrasound image. Hence, it is critical to identify the suitable speckle filtering method to eliminate the speckle noise in order to identify the eggs in the gonad ultrasound image. This paper will compare the speckle filtering methods and identify the suitable method that can be used to eliminate the speckle noise in the mahseer's gonad ultrasound image.

2. Methodology

This paper emphasized on the comparison of the speckle filtering methods in the gonad ultrasound image and identifies the suitable methods that can be used to eliminate the speckle noise in the mahseer's gonad ultrasound image which lead to precisely identify the eggs in the gonad. Therefore, in this experiment, there are two stages that need to be conducted, which are (i) image acquisition, and (ii) filtering the speckle noise.

2.1 Image Acquisition

There are twenty mahseer's gonad ultrasound images provided by the Agro-Biotechnology Institute (ABI) are used in the experiment. These images are obtained from ultrasound unit, ALOKA SSD-900 with 7.5MHz Bi-Plane probe and the images includes the immature and mature eggs in the gonad area as shown in Figure 1. Figure 1 (a) show the raw ultrasound image of immature or no egg because of the 'V' shape. While, in the Figure 1 (b) show the raw ultrasound image that have the mature eggs.

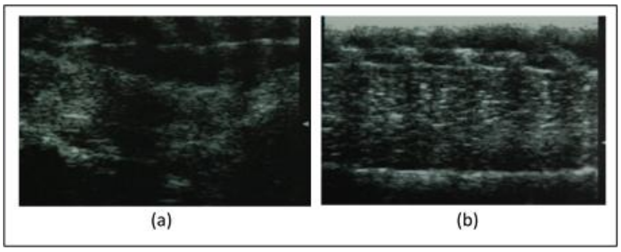

Fig. 1: Mahseer's raw ultrasound image. (a) Immature or no egg. (b) Mature eggs.

The aim of this experiment is to eliminate the speckle noise in order to identify the eggs in the gonad ultrasound image. In order to do the experiment, only the images with mature eggs are used because it will be easier to analyze the difference between eggs and the speckle noise in the ultrasound image. Out of twenty images that were obtained from ABI, only ten images display the mature eggs. Thus, these ten images will be processed to eliminate the speckle noise in order to identify the eggs in the gonad ultrasound image

2.2 Filtering the Speckle Noise

It is challenging to differentiate between the speckle noise and the eggs in the mahseer's gonad since there are both have the similarity and only have subtle difference. For that reason, it is necessary to filter the speckle noise in ultrasound image using speckle filtering method. At this stage, the original image as shown in Figure 2 are used in the experimental setup to identify the suitable speckle filtering methods. There are five speckle filtering methods, which are Mean [32], Median [33], Wiener [32], Speckle Reducing Anisotropic Diffusion (SRAD) [34] and Optimized Bayesian Non-local Means (OBNLM) [35] were applied in the image.
Before that, a preliminary experiment to find the parameter used in each of the speckle filtering methods in order to eliminate the speckle noise have been conducted. The parameter values used in this preliminary experiment as shown in Table 1. In order to find the best quality of filtered image, image quality measurement which are Signal-to-Noise ratio (SNR) [36], Peak-Signal-to-Noise ratio (PSNR) [36] and Structural Similarity Index (SSMI) [37] are used to measure the filtered image.

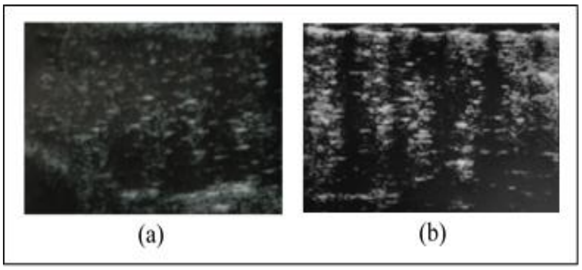

Fig. 2: Original image (input image). (a) Image 1. (b) Image 2.

3. Results and Discussion

The result of the experimental setup that have been conducted in this research study are highlighted in this section. As mentioned in the methodology section, the experiment is to identify the suitable speckle filtering method in eliminating the speckle noise in the ultrasound image by comparing these five speckle filtering methods.
A preliminary experiment has been conducted in order to indicate the appropriate parameter value used in each speckle filtering methods. The SNR, PSNR and SSMI are calculated as depicted in Tables 2 and 3, in order to evaluate the quality of the image

Table 1: Parameter values used for Mean, Median, Wiener, SRAD and OBNLM.

METHOD	PARAMETER USED	VALUE
Mean	Window size	3x3
Median		5x5
Wiener		7x7
SRAD	Iteration number	10
		15
		20
OBNLM	Smoothing parameter	0.3
		0.7
		1.2

From the results shown in Table 2, 3x3 window size demonstrate the good image quality because of the higher SNR and PSNR values in images 1 and 2, compared to 5x5 and 7x7. In image 1, the PSNR for the Mean filter in 3x3 is 8% higher than 5×5 and 14% higher than 7×7. While for the Median filter, the PSNR in 3x3 is higher than 8% higher than 5×5 and 14% higher than 7×7. Then, as for Wiener filter, the PSNR in 3x3 is 8% higher than 5×5 and 15% higher than 7×7. While, in image 2, the PSNR for the Mean filter in 3x3 is 14% higher than 5x5 and 24% higher than 7x7. While for the Median filter, the PSNR in 3x3 is 15% higher than 5x5 and 25% higher than 7x7. Then, as for Wiener filter, the PSNR in 3x3 is 10% higher than 5x5 and 19% higher than 7x7.Therefore, it is proven that 3×3 window size value will be used as the parameter for Mean, Median and Wiener speckle filtering methods.
While, for SRAD filter, it shows that the good filtered image goes to 10 iterations compared to 15 and 20 as shown in Table 3. In image 1, the SNR for 10 iterations is 13% higher than 15 iterations and 23% higher than 20 iterations. While, in image 2 the SNR is 20.080 which is 13% higher than 15 iterations and 23% higher than 20 iterations. While for the OBNLM filter show that 0.3 smoothing parameter has the highest value of SNR and PSNR compared to 0.7 and 1.2. In image 1, the PSNR in the 0.3 smoothing parameter is 20.000 which is 1% higher than smoothing parameter 0.7 and 2% higher than smoothing parameter 1.2. While, in image 2, the PSNR in the 0.3 smoothing parameter is 27.206 which is 3% higher than smoothing parameter 0.7 and 3% higher than smoothing parameter 1.2. Therefore, 10 iterations are used for SRAD and 0.3 smoothing parameter is used for OBNLM as the parameter value in the experiment.
Based on these preliminary experimental results as shown in Tables 2 and 3, main experimental setup to determine the suitable speckle filtering method for eliminating the speckle noise in the gonad ultrasound image have been conducted. Five speckle filtering methods, which are Mean, Median, Wiener, SRAD and OBNLM are compared. The setup of the parameters for each filter as shown in Table 4. Using the parameters in Table 4, the experiment is executed and the result of each filter is presented in Figure 3. From the observation in Figure 3, it is demonstrated that these five filters can eliminates the speckle well, but Mean filter as shown in Figure 3 (a) eliminates the sharp details in the image.

Whereas, the Median filter as shown in Figure 3 (b) cannot differentiate the quality details from the noise, but it has improved visualization compared to Wiener. Wiener filter as shown in Figure 3 (c) make some of the details lost, over-enhanced and image become more blurred. OBNLM as shown in Figure 3 (d) can lead to over-filtering due to the loss of original information during diffusion process and SRAD as shown in Figure 3 (e) also can lead to over-filtering by destroying some of the image details although it can smooth out the speckle successfully. In order to verify the observation, the filtered images are evaluated by using PSNR, SNR and SSMI to analyze the quality of the image as depicted in Table 5.

Table 2: Result Image Quality Measurement for Mean, Median, and Wiener with Different Parameters.

METHOD	PARAMETERS	SNR		PSNR		SSMI	
		Image 1	Image 2	Image 1	Image 2	Image 1	Image 2
Mean	3x3	27.084	28.383	38.464	40.388	0.967	0.978
	5x5	23.918	22.529	35.299	34.533	0.945	0.940
	7x7	21.605	18.752	32.986	30.756	0.918	0.881
Median	3x3	31.485	31.621	42.866	43.626	0.981	0.985
	5x5	28.028	24.968	39.408	36.973	0.963	0.958
	7x7	25.457	20.802	36.837	32.806	0.943	0.912
Wiener	3x3	31.212	31.090	42.592	42.094	0.970	0.977
	5x5	27.506	25.884	38.887	37.889	0.950	0.959
	7x7	24.788	22.228	36.168	34.232	0.938	0.918

Table 3: Result Image Quality Measurement for SRAD and OBNLM with Different Parameters.

METHOD	PARAMETER	SNR		PSNR		SSMI	
		Image 1	Image 2	Image 1	Image 2	Image 1	Image 2
SRAD	10	20.080	19.430	31.461	31.435	0.936	0.917
	15	17.337	16.944	28.718	28.948	0.911	0.879
	20	15.383	15.202	26.764	27.206	0.887	0.845
OBNLM	0.3	8.621	14.485	20.000	27.206	0.910	0.914
	0.7	8.430	14.355	19.810	26.360	0.907	0.906
	1.2	8.234	14.265	19.615	26.270	0.898	0.889

Table 4: The Window Size, Iteration Number and Smoothing Parameter used in the Speckle Filtering Methods.

METHOD	WINDOW SIZE	ITERATION	PARAMETER
Mean	3x3	-	-
Median	3x3	-	-
Wiener	3x3	-	-
SRAD	-	10	-
OBNLM	-	-	0.3

Table 5: Result Image Quality Measurement for Speckle Filtering Method.

METHOD	SNR		PSNR		SSMI	
	Image 1	Image 2	Image 1	Image 2	Image 1	Image 2
Mean	27.084	28.383	38.464	40.388	0.967	0.978
Median	31.485	31.621	42.866	43.626	0.981	0.985
Wiener	31.212	31.090	42.592	42.094	0.970	0.977
SRAD	20.080	19.430	31.461	31.435	0.936	0.917
OBNLM	8.621	14.485	20.000	27.206	0.910	0.914

From the result in measuring the image quality shows in Table 5, Median filter demonstrate the best speckle filtering method because of the higher SNR and PSNR values compared to other four speckle filtering methods and the results also were justified by the experts. In image 1, the SNR value for Median is 31.485 which is 14% upper than Mean, 1% upper than Wiener, 36% upper than SRAD and 73% upper than OBNLM. As for PSNR value for Median is 42.866 which is 10% upper than Mean, 1% upper than Wiener, 27% upper than SRAD and 53% upper than OBNLM. While, in image 2, the SNR value for Median is 31.621 which is 10% upper than Mean, 2% upper than Wiener, 39% higher than SRAD and 54% upper than OBNLM. As for PSNR value for Median is 43.626 which is 7% upper than Mean, 4% upper than Wiener, 28% upper than SRAD and 38% upper than OBNLM.

4. Conclusion

From the experiment in this paper, it is proven that Median filter can be used to eliminate the speckle noise in the mahseer's gonad ultrasound image without removing the fish eggs also. Besides, ultrasound as the noninvasive tool obviously can be used to keep track on the fish gonad maturation especially mahseer's fish.

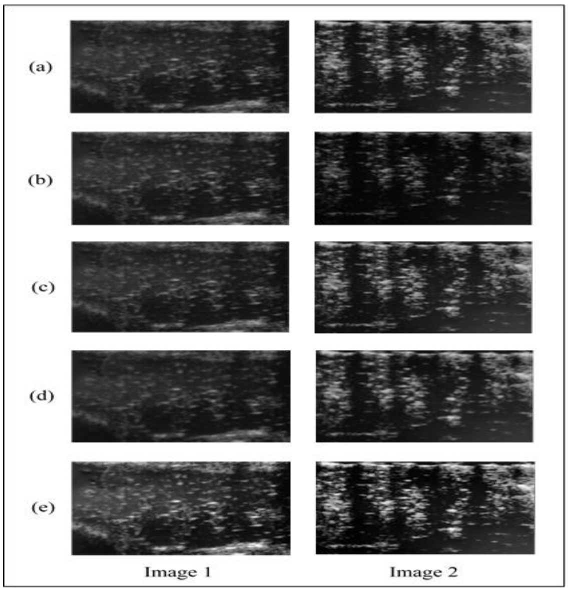

Fig. 3: Result of speckle filtering method. (a) Mean. (b) Median. (c) Wiener. (d) SRAD. (e) OBNLM.

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