AN IMPROVED IMAGE FILTERING METHOD FOR WELD BEAD INSPECTION USING UNSHARP MASKING TECHNIQUE

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Article History: Received 3 August 2017; Revised 22 October 2017; Accepted 28 December 2017

ABSTRACT: There are many disturbances that occur during image capturing process. One of the common disturbances is noise. Consequently, various methods were developed to improve image quality. In this study, the proposed method consists of an enhanced Unsharp Masking Technique that is combined with common filtering methods. The method was applied in different noise situations. The image filtering methods involved were common filter which Mean, Median and Gaussian filters. The images of welding process were converted into RGB for ease of calculation. Mean Square Error (MSE) and Peak Signal to Noise Ratio (PSNR) were used to determine the quality of the image. Graph generated to reinforce the PSNR value. The results obtained proved that the proposed method could yield better filtering performance.

KEYWORDS: *Noise Image; Unsharp Masking; Mean Filter; Median Filter; Gaussian Filter; PSNR*

1.0 INTRODUCTION

The welding process is a joining process that mostly used in manufacturing industry. This process or its variation was used for deposition of material on a surface. The purpose of this is actually to recover worn parts or to form a coating with special characteristics [1]. Welding itself has many types which are MIG welding, Arc welding, Gas welding and TIG welding. The most famous welding technique is MIG welding [2-4]. Besides that, welding is a major joining process for fabricating and assembling various structures such as cars body, ships, pipelines, and offshore drilling plate forms. This paper focuses on developing a new vision inspection system using machine vision. Weld butt joint is made by using MIG welding, is classified and identified.

The overall results of the new vision inspection are about 90 % compared to the real sample tested [4]. Weld bead inspection is important for obtain good quality in welding. This process works on measurement, monitoring and defect detection using structured-light based on vision inspection system. This experiment is held with a satisfactory result for online inspection [3]. Another kind of welding is explosive welding. Explosive welding is a welding technology that combined flyer plate with a base plate by a great pressure produced from detonation. Numerical simulation is used to study about explosive welding for large-sized plates. The calculated result is good which satisfy the output of practical projects [5].

In order to detect welding defect automatically, radiography and neural approach are applied. Inspection of welding defect using radiography is made by edge detection method of radiographic image based on Multilayer Perceptron (MPC). The aim of this process is to classify and recognize the welding defect successfully with default percentage [6]. Besides that, geometric of feature also been used in order to detect defect on welding because constraint of human inspector [5, 7].

Welding seam is detected using two methods. First is Frame Difference Testing (FDT). It is based on data extraction taken from D-S evidence theory. This is used to improve the reliability of welding seam defect detection by reducing the rate of false alarm. Based on the the experiment result, it shows that the method have 90 percent accuracy and may fulfill real-time inspection [8]. The second method is the column gray-label accumulation inspection (CAI). Using this method, the original curve is produced by implementing the accumulation sequence of process, then by exerting the mean value smoothing operation. The first difference is needed for the curve in order to segment the defects of welding seam. Consequently, the developed welding path measuring system (WPMS) has improved the weld deposits in multi-pass and repair welding by having stereo vision measurement of the arc position in 3D space [9].

Quality inspection is one of the most critical aspects of the manufacturing industry. This is to ensure that the final products delivered comply with the standard. Therefore, it is important to have an efficient vision inspection system to ensure that the system is reliable to replace human inspection. With regards to the welding processes, there are some factors that need to be considered when designing a vision inspection system. One of the factors is how to eliminate or filter noises from image of weld beads. Noises typically occur especially due to the improving illumination of lighting, the presence of sharp and sudden welding sparks and vibration of equipment and work piece, especially during operation. Conventional image processing methods proved to be insufficient to directly process the image. Therefore, this study proposes an enhancement of image filtering methods to improve the image processing capability. The aim of this study is to obtain high efficiency image filtering system to address the problem.

2.0 METHODOLOGY

2.1 Filtering of Image Noise for Weld Bead Product

Image processing is a growing field covers a full range of techniques for the manipulation of digital images [3, 10]. It is the most important technique to improve the quality of image enhancement. Digital image processing has helped in the access of technical data such as digital services of computers. It helps in terms of speed processing of data and the possibilities of big storage [11]. A new entrant of image processing is in Friction Stir Welding (FSW) and getting defect-free weld [12].

Image noise is an unwanted declaration of the image because its decrease the quality of the image. To enhance it, a filtering technique is used. Filtering techniques mainly used for de-noising, sharpening and smoothing the image by extract useful information from the image [11-13]. There are many types of noise disturbance in an image. The image noise can be classified into eight classes.

For choosing the type of filter, it is based on the nature of the image whereby noise occurs in the image. The filter is used in order to remove noise in a digital image. The original data of the image is preserved without losing a single bit of the information from the image taken. Filters can be described with by different categories [14]. The Gaussian filter is an example of linear filtering while the median filter is an example of a non-linear filter. A modified directional adaptive median filter is been proposed in eliminating heavy noise and high density with 70 % of image noise. The proposed method efficiently removed the noise and preserved detailed information of the image [15]. Besides that, Kalman filter has also been used to detect a defect in real-time radiographic NDT of spiral pipes. The Kalman is used to detect true defect [16]. In order to reduce noise, the iterative impulse noise filters cannot do it properly. So, an automatic filtering convergence method is applied to address the problem. The results show the method can remove much of impulse noise and preserved image details [17].

The process flow of this study is illustrated in Figure 1. In image acquisition process, the image is recalled from database. The image of butt weld image is captured. The image of the rejected butt weld is due to the defect occur. The second process is image processing where the image is converted into RGB with the intensity value of image is 0-255. After that, the grayscale image is de-noising with impulse noise. 10 % of salt and pepper noise with speckle noise were added to the raw image to test filtration.

The image corrupted by noise is applied for filtering process. The filtering techniques involve are linear filter (mean) and non-linear filter (median). Finally, the quality of image is validated using Mean Square Error (MSE) and Peak Signal to Noise Ratio (PSNR). In order to reinforce the PSNR result, the graph is generated based on a number of pixel value that produced from the image.

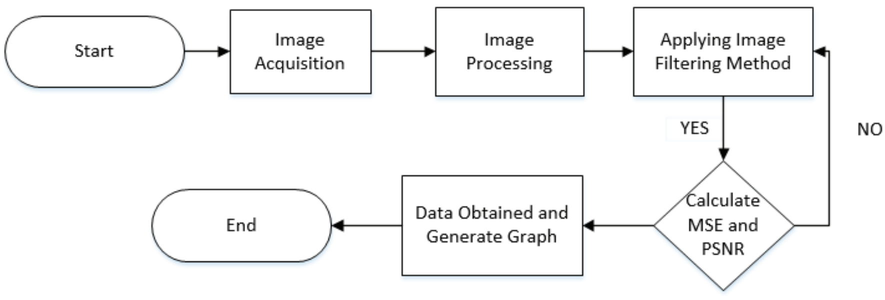


Figure 1: Process flow of image filtering method

2.2 Enhanced Image Filtering Method

Image filtering method which used in this study is common filtering methods which are Mean Filter, Median Filter, and Gaussian Filter. The filters are chosen based on their ability to remove noise as discussed in the previous section. For linear filter, it will make the image smoother while non-linear filter will remove noise while saving the valuable pixel. Nevertheless, conventional image processing methods proved to be insufficient to directly process the image. Therefore, this study proposes an enhancement of image filtering methods to improve the image processing capability by using Linear Unsharp Masking technique [18] prior to the filtering. The block diagram is illustrated in Figure 2.

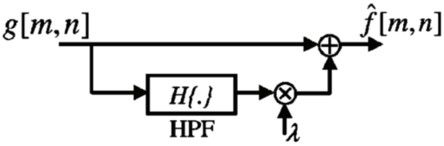


Figure 2: Block diagram for Linear Unsharp Masking technique [18]

In order to improve the performance of image filtering method, this study proposes Linear Unsharp Masking technique to be implemented prior to the filtering. The technique can be described as in Equations (1) and (2):

$$f[m, n] = g[m, n] + \lambda\lambda H\{g[m n]\} \tag{1}$$
$$= g[m, n] + \lambda\lambda(g[mn] - L\{g[m, n]\})$$
$$= (1 + \lambda\lambda)g[m n] - \lambda\lambda L\{g[m n]\} \tag{2}$$

where H{·} and L{·} are a high pass filter and a low pass filter respectively. After the filtering, the image is calculated using PSNR. Based on the PSNR result, the greatest value is the best quality of the image.

3.0 EXPERIMENTAL RESULT

Table 1 depicts the condition of corrupted image present with speckle noise, salt and pepper noise, and, the result of filtered image. The result shown is based on three types of famous filtering process which are Mean Filter, Median Filter, and Gaussian Filter.

The first image (a) is corrupted image with speckle noise, while the second image (b) is corrupted image with filtering image using Mean filter. However (c) and (d) is corrupted image that using Median filter and Gaussian filter. The (e) image is corrupted image with 10% of salt and pepper noise. In addition, the (f), (g), (h) image is the image filtered using Mean, Median and Gaussian filter.

In order to improve the quality of the image for both corrupt image types, a proposed method had generated. The resulting image of proposed filter shown in Table 2. The filtering process involves the Mean filter, Median filter and Gaussian filter are shown in the following equations:

$$\hat{f}(x, y) = \frac{1}{mn} \sum (s,t) \in S_{xy} g(s,t) \tag{3}$$

$$\hat{f}(x,y) = \text{median}(s,t) \in S_{xy}\{g(s,t)\} \tag{4}$$

where

$\hat{f}(x,y)$ = average value of corrupted image

mn = size of image

S_{xy} = area or window (kernel)

$$G_\sigma = \frac{1}{2\pi\sigma^2}\{-\frac{x^2+y^2}{2\sigma^2}\} \tag{5}$$

where

G_σ = average value of corrupted image

σ = variance

3.1 Improvement

Table 2 shows a grayscale image from original image. Besides that, it also shows image of improve filter for speckle noise, and salt and pepper noise. Improve filter is applied to get a better result in filtering of image noise.

Table 1: Restored butt welding corrupted image and filtered for speckle noise and salt and pepper noise: (a) Corrupted image with speckle noise; (b) Image corrupted filtered by Mean filter; (c) Image corrupted filtered by Median filter; (d) Image corrupted filtered with Gaussian filter; (e) Corrupted image with salt and pepper noise; (f) Image corrupted filtered by Mean filter; (g) Image corrupted filtered by Median filter and (h) Image corrupted filtered by Gaussian filter

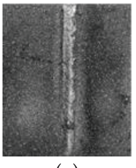
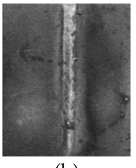
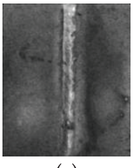
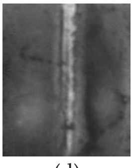
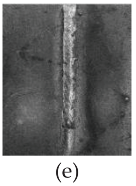
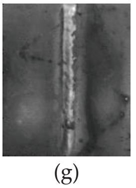
Type of Noise	**Image + Noise**	**Image Filtering Method**		
		Mean	**Median**	**Gaussian**
Speckle Noise	 (a)	 (b)	 (c)	 (d)
Salt and Pepper Noise	 (e)	 (f)	 (g)	 (h)

Table 2: Restored image of improvement filter for image corrupted with speckle noise and image corrupted with salt and pepper noise

Image		
Grayscale Image	**Improve Filter for Speckle Noise**	**Improve Filter for Salt and Pepper**
		

The PSNR and MSE are denoted by Equations (6) and (7) are used to evaluate the effectiveness of the proposed filtering method.

$$PSNR = 10\log 10[(R/MSE)^2] \quad (6)$$

Where
R = Maximum fluctuation in the input image data type and

$$MSE = \sum \frac{1}{M * N}\left[I_1(M_1, N) - I_2(M_2, N)\right]^2 \quad (7)$$

Where
I_1 and I_2 = First and second images
M = Number of rows in the input image
N = Number of columns in the input image

3.2 Result of the Filtering of Weld Bead Image

By using PSNR equation, the quality of image filter was calculated. Before PSNR data are obtained, MSE (Mean Square Error) data is used to calculate it. Table 3 shows result of MSE, PSNR and Time elapsed data. In the table, the data is for speckle noise image, salt and pepper noise image. The first result of image noise is applied for Mean filter. Then, the second result is applied for Median filter. The third result is for Gaussian filter and the last result is for filter improvement.

4.0 DISCUSSION

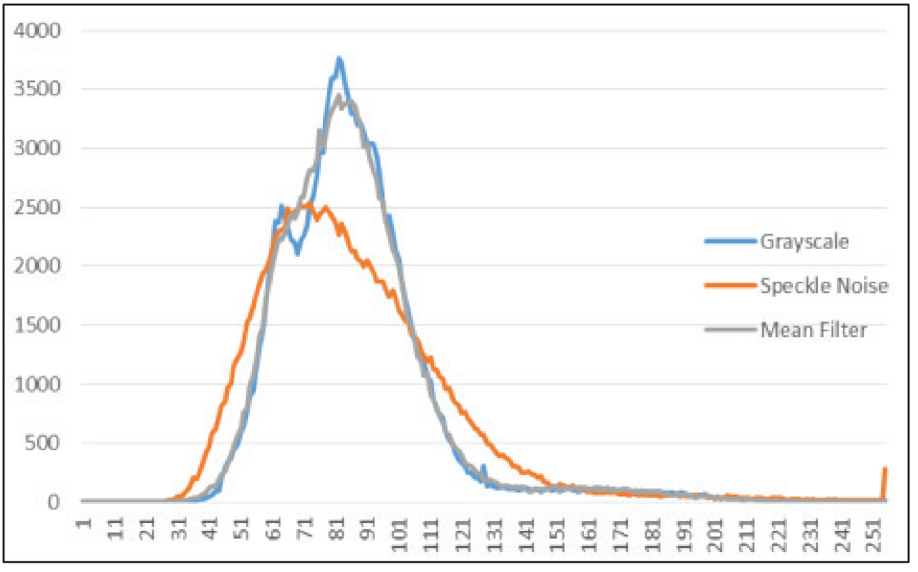
The corrupted image was applied with three common image filtering methods as depicted in Table 1. The methods utilized are Mean filter, Median filter, and Gaussian filter. The image after filtering is shown. In order to improve the obtained result from Table 1, an improved method is proposed. The improved method shows better result compared to the common image filtering method. The improved filter is based on the common filter that does a good filtering from the image noise.

The result obtained from Table 3 shows the PSNR values for each of image filtering method. From the result obtained from common filter, it is found that Mean filter has the highest value of PSNR for speckle noise which is 76.9160. Meanwhile, for the salt and pepper noise, Median filter has the highest value which is 77.9816. However, when the improved filter is applied for both corrupted image, the PSNR value is increased. Based on the PSNR rule, the higher the value of PSNR, the better the image quality will be. However, for both noise, Gaussian filter did not show a good PSNR result.

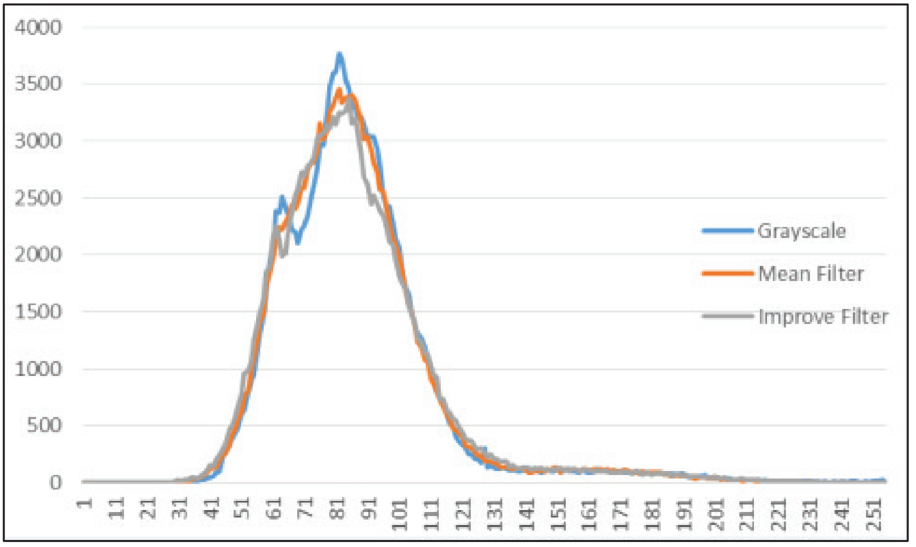
In addition, the PSNR results of the image filtering method are supported by graph generated based on pixel count. For the graph, Figure 3(a), it shows pixel count of highest PSNR value of speckle noise image which is Mean filter. The graph shows that filtered image is approaching grayscale image (original) which is higher than noise image. While graph in Figure 3(b) shows comparison between improve filter and Mean filter for speckle noise. The graph shows, the improved filter is more closed to the grayscale image. Apart of that, Figure 3(c) shows the graph filtering of salt and pepper noise. From the PSNR, Median filter has the highest value. The graph illustrates comparison between the Median filter with the grayscale image. The filtered image has a graph that approaching grayscale image. Then, Figure 3(d) for the improved filter is generated. The graph of improved filter is compared with median filter. The graph of improve filter is better than median filter. The finding of this study shows that combination of Unsharp Masking technique and conventional method could improve the filtering quality. This is consistent with the finding previously done [18].

Table 3: Result of generated image

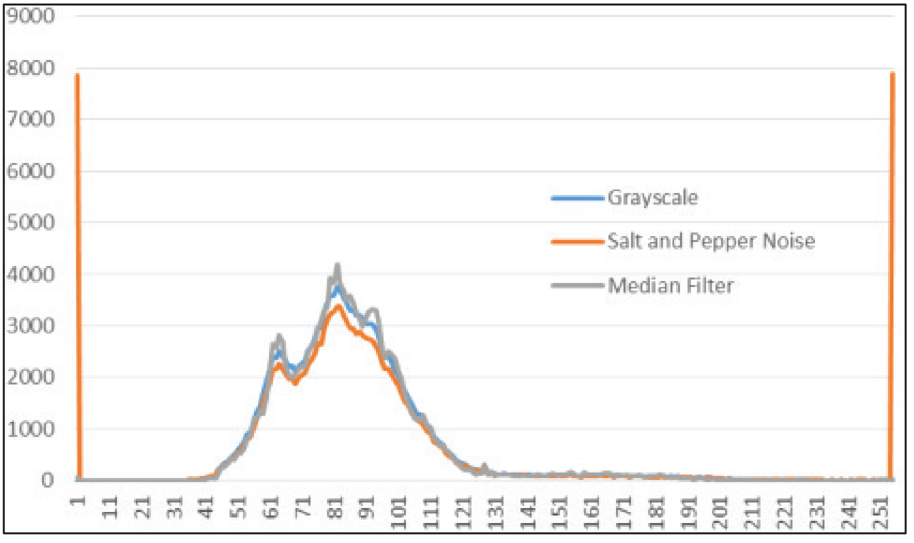
No	Image Noise >Type of Filter	MSE		PSNR (dB)		Time Elapsed (s)	
		Speckle Noise	Salt and Pepper Noise	Speckle Noise	Salt and Pepper Noise	Speckle Noise	Salt and Pepper Noise
1	Noise > Mean	0.03637	0.06492	76.9160	71.8830	0.1072	0.9249
2	Noise > Median	0.04004	0.03217	76.0803	77.9816	0.3026	0.7402
3	Noise > Gaussian	0.04101	0.04752	75.8721	74.5930	0.1376	10.3996
4	Noise > Improver	0.01196	0.00935	86.5757	88.7131	0.4909	0.4625



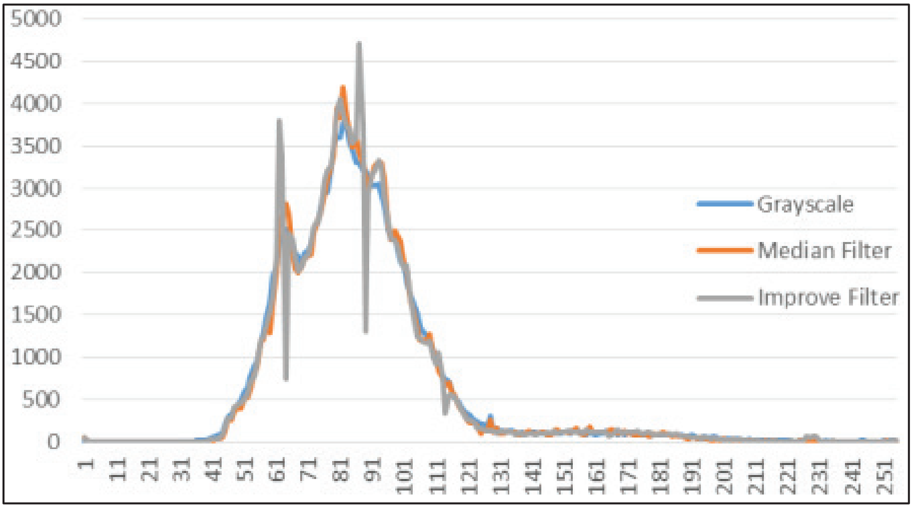
(a)


4000
3500
3000
2500
2000
1500
1000
500
0
1
11
21
31
41
51
61
71
81
91
101
111
121
131
141
151
161
171
181
191
201
211
221
231
241
251
Grayscale
Mean Filter
Improve Filter

(b)


9000
8000
7000
6000
5000
4000
3000
2000
1000
0
1
11
21
31
41
51
61
71
81
91
101
111
121
131
141
151
161
171
181
191
201
211
221
231
241
251
Grayscale
Salt and Pepper Noise
Median Filter

(c)



(d)

Figure 3: The graph of image filters: (a) Image filter of speckle noise; (b) Improved image filter of speckle noise; (c) Image filter of salt & pepper noise; (d) Improved image filter of salt & pepper noise

5.0 CONCLUSION

As the conclusion, from the experiment, the improved filter is producing better result in filtering image corrupted by speckle noise and salt and pepper noise. Based on the PSNR result and the graph, it shows that by integrating Unsharp Masking technique with conventional filters, higher accuracy of filtering could be obtained. Using the PSNR to evaluate the first part of filtering, the improved filter has its flexibility to incorporate with different types of image noise.

ACKNOWLEDGEMENT

This present work is part of the Fundamental Research Grant Scheme, Project Code FRGS/1/2014/TK01/FKP/02/F00218. The authors also wish to thank Malaysian Ministry of Higher Education for the financial support and Universiti Teknikal Malaysia Melaka.

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