MNK Publication
*International Journal of Latest Research in Science and Technology* **ISSN (Online):2278-5299**
*Volume 2, Issue 6: Page No.38-43 ,November-December 2013*
*https://www.mnkpublication.com/journal/ijlrst/index.php*

# AN EFFICIENT IMAGE ENHANCEMENT ALGORITHM FOR SONAR DATA

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***Abstract-*** ***This study proposes an alternative effective sonar image enhancement algorithm. The method basically composes of two steps, including noise reduction and image sharpening. The sonar image is first de-noised using Wiener and median filters, and then it is enhanced using unsharp masking and histogram equalization. The proposed algorithm has been verified on many sonar images of different underwater structures, and shows its efficiency comparing to some well-known sonar noise reduction methods applying for sonar image data.***

***Keywords*** **–** Sonar image processing; sonar noise reduction; local statistic filters

## I. INTRODUCTION

The quality of sonar images is often reduced by noise and/or blur. They therefore usually lead to incorrect analysis and decrease the usefulness for human, semi-automatic and automatic interpretation. In reality, many efficient de-noising techniques have been introduced for sonar data such as median filters [1, 2], local statistic methods [3-5], wavelet transform [6-9], etc.

Median filters [1, 2] are utilized for de-speckling due to their robustness against the impulse noise while preserving image features.

Lee filter [3] forms an output by computing a linear combination of the centre pixel intensity in a predefined size of filter window with the average intensity of the window. Kuan filter [4] has the same formulation with Lee filter although the signal model assumption and derivations are different. These two filters achieve a balance between straightforward averaging in homogeneous regions and identity filter where the edges and point feature exist. Frost filter [5] achieves a balance between averaging and all pass filter by forming an exponentially shaped filter kernel. This filter is considered as an adaptive Wiener filter that convolves the pixel values within a fixed size window with an exponential impulse response. The response of the filter varies locally with the coefficient of variation.

Zong, et al. [6] and Hao, et al. [7] proposed a speckle noise reduction technique using wavelet-based filters. The image is first converted into the wavelet domain. Then the wavelet coefficients that are smaller than a predefined threshold are considered as noise, and they should be removed. Thus the prior knowledge on input data plays an important role in choosing the optimal threshold value. The wavelet coefficient statistical models were proposed by Sendur and Selesnick [8], and Achim and Kurouglu [9] in 2002 and 2005 respectively. The noise suppression is done with the help of MAP filters. Recently, Isar, et al. [10] introduced a new de-noising algorithm using wavelet transform association with Maximum A Posteriori (MAP) filter. The image is converted into wavelet domain, and then the MAP filter, so-called the Bishrink filter, is utilized for noise suppression.

However, most of the above-mentioned methods focus on the noise reduction. Thus finding an alternative algorithm, which can offer noise reduction together with image de-blurring, is the main motivation of this study.

In this study, an efficient two-step Sonar image enhancement is presented. In the first step, the sonar image is undergone noise reduction process by means of Wiener and median filters. Then the filtered image is de-blurred and enhanced contrast using unsharp masking process and histogram equalization.

## II. THE PROPOSED IMAGE ENHANCEMENT ALGORITHM

The algorithm is summarized in Figure 1. However, in this study the input sonar images are assumed to be geometric and slant-range correction before applying the proposed algorithm.

The algorithm basically consists of two steps, noise cancelling and image sharpening. The Weiner and median filters are utilized to suppress noise, and then the filter image will be de-blurred and enhanced using unsharp masking and histogram equalization.

Wiener filter is one of the popular techniques for removal of blur in images due to linear motion or unfocussed optics [11, 12]. The Wiener filtering executes an optimal tradeoff between inverse filtering and noise smoothing. It can remove the noise and the de-blurring simultaneously, and the Wiener filtering is optimal in terms of the mean square error. In other words, it minimizes the overall mean square error in the process of inverse filtering and noise smoothing [13].

**Publication History**
*Manuscript Received : 25 December 2013*
*Manuscript Accepted : 28 December 2013*
*Revision Received : 30 December 2013*
*Manuscript Published : 31 December 2013*

Median filters can do an excellent job of rejecting certain types of noise, in particular, “shot” or impulse noise [14]. In a median filter, the neighboring pixels are ranked according to brightness (intensity), and then the median value becomes the new value for the central pixel, and median filters offer three important advantages [15]:

- No reduction in contrast across steps, since output values available consist only of those present in the neighborhood (no averages).
- Median filtering does not shift boundaries, as can happen with conventional smoothing filters (a contrast dependent problem).
- Since the median is less sensitive than the mean to extreme values (outliers), those extreme values are more effectively removed.

Unsharp masking is one of the popular ways of image sharpening. In the unsharp masking process, an image is sharpened by enhancing the high frequency components of the image, which is mainly enhancing the edges. Thus, to increase sharpness in an image we need a good high-pass filter. Unsharp masking is done by adding a fraction of high-pass filtered image to the original image. In more details, the unsharp masking process increases the sharpness of the edges in the image and thus reduces the blur or the dullness in the image. It is believed that performance of unsharp masking depends on the high-pass filter used, and there are many mask filters can be used such as Gaussian, Lapacian, Lapacian of Gaussian, Sobel, Prewitt [15].

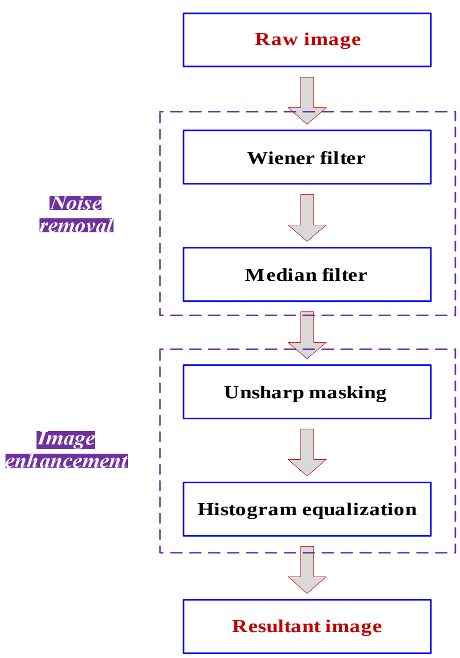


Fig. 1 Sonar image enhancement algorithm.

Histogram equalization is a method in image processing of contrast adjustment using the image's histogram [15, 16]. This method usually increases the global contrast of many images, especially when the usable data of the image is represented by close contrast values. Through this adjustment, the intensities can be better distributed on the histogram. This allows for areas of lower local contrast to gain a higher contrast. Histogram equalization accomplishes this by effectively spreading out the most frequent intensity values. The method is useful in images with backgrounds and foregrounds that are both bright or both dark. In many practical applications, histogram equalization can lead to better detail in photographs that are over or under-exposed. A key advantage of the method is that it is a fairly straightforward technique and an invertible operator. So in theory, if the histogram equalization function is known, then the original histogram can be recovered, and the calculation is not computationally intensive.

The sonar images of some underwater structures were recently collected in Korea in 2013 including the swimming pool, spillway, and floodgate. Some selected data are used to verify the performance of the proposed methods.

Figures 2-5 show the results of the proposed algorithm comparing to some well-known noise reduction methods for sonar images (Lee, Kuan, and Forst methods [3-5]). The proposed method shows very good performance in terms of sonar image enhancement.

## III.CONCLUSIONS

This study introduces an alternative effective algorithm for sonar image enhancement. The proposed algorithm consists of two steps including noise reduction and image enhancement. The Wiener and median filters are used for de-noising, the filtered image is then enhanced using unsharp masking and histogram equalization.

The experimental results show that the proposed algorithm is efficient in terms of noise reduction, and sharpening sonar images.

## ACKNOWLEDGMENTS

This study was supported by a grant (11CTIP-D03) from Construction & Transportation Technology Advancement Research Program sponsored by Ministry of Land, Infrastructure and Transport of Korean government. Their supports are greatly appreciated.

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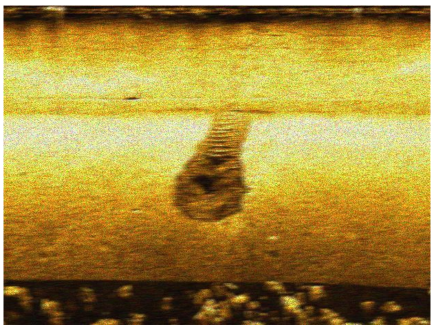
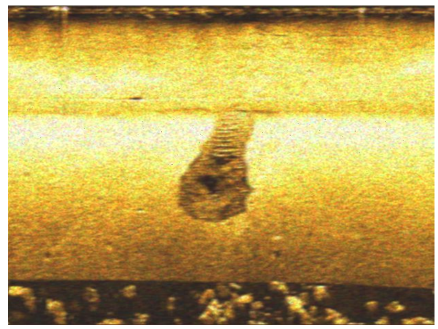
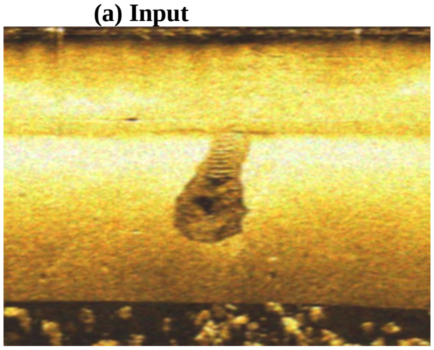


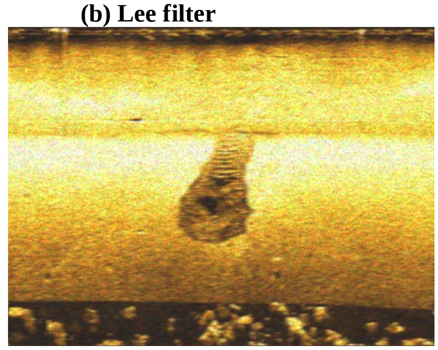
**(a) Input**



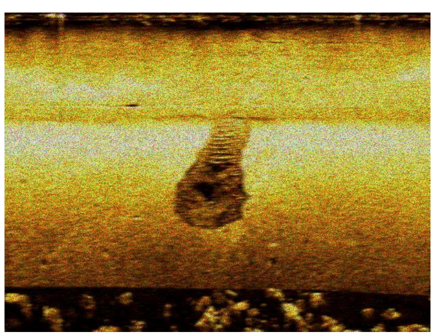
**(b) Lee filter**



**(c) Frost filter**

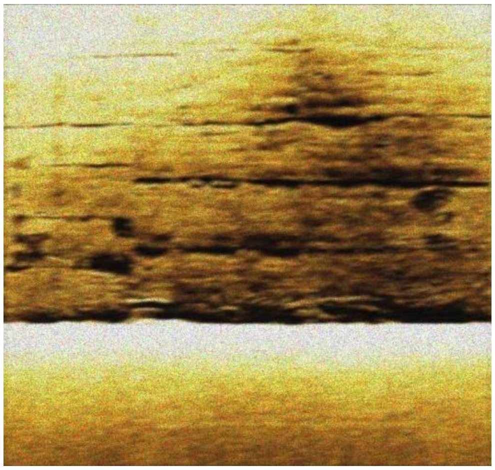


**(d) Kuan filter**

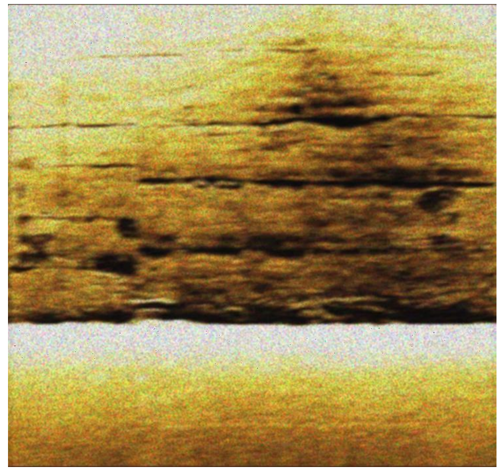


**(e) Proposed algorithm**

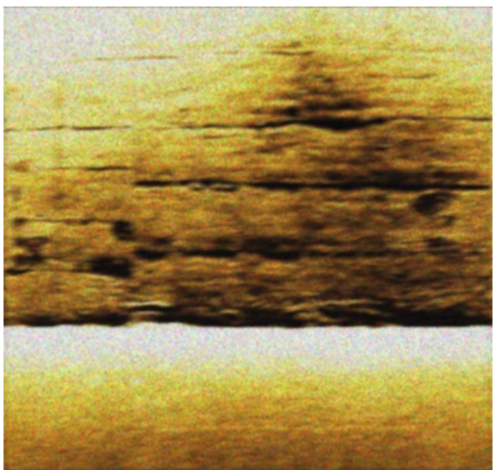
**Fig. 2. Damage in a swimming pool.**



(a) Input



(b) Lee filter



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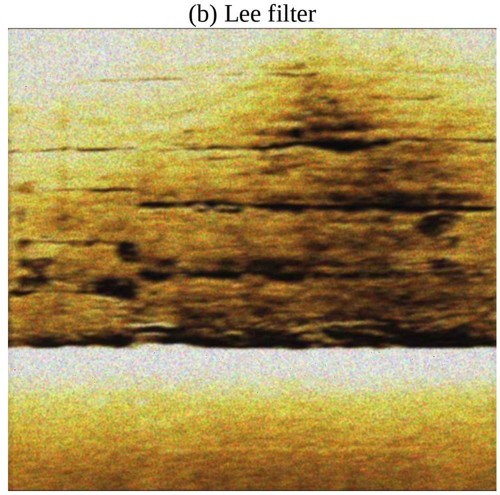
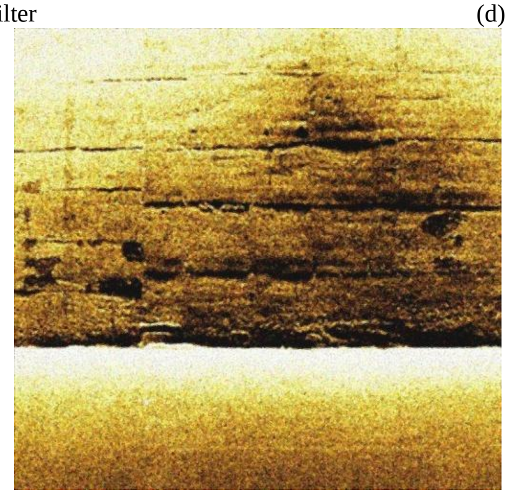
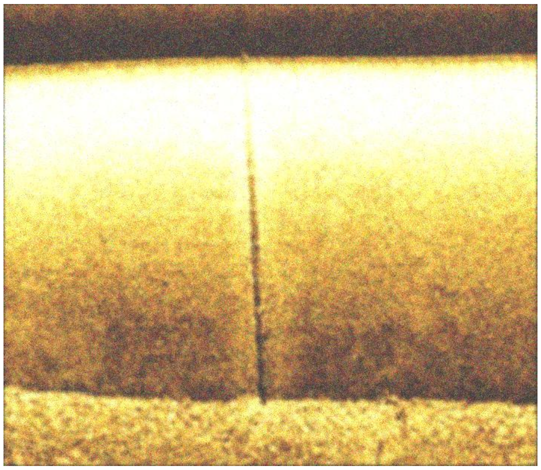


(d) Kuan filter

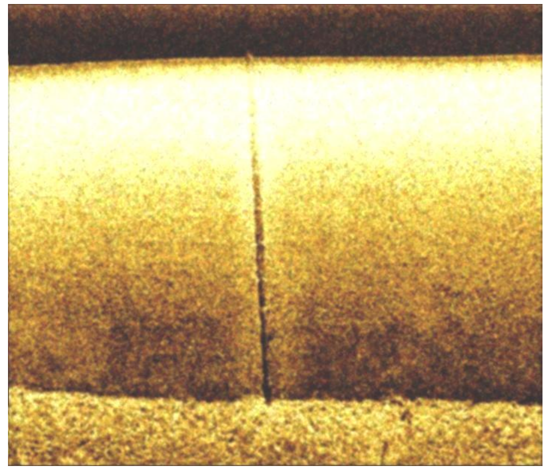


(e) Proposed algorithm

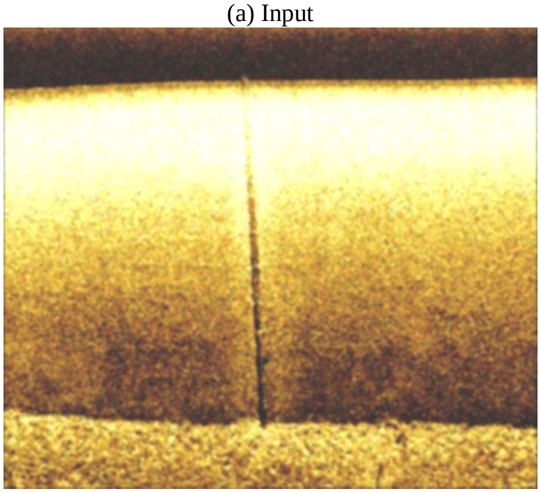
**Fig. 3. Damage on a spillway.**



(a) Input



(b) Lee filter



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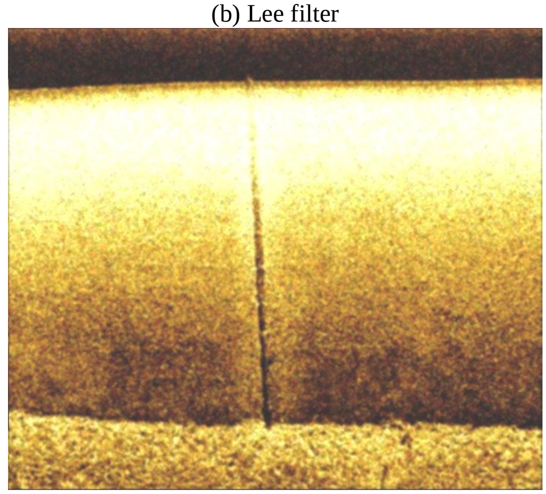

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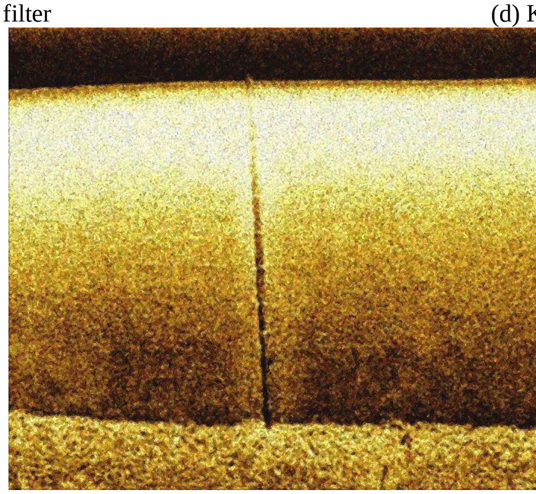
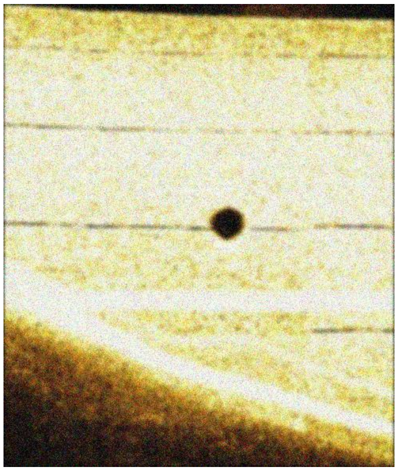


(e) Proposed algorithm



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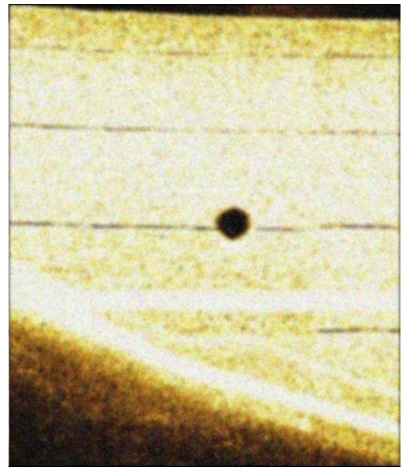
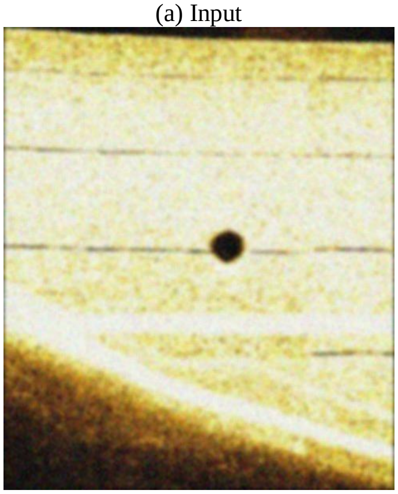
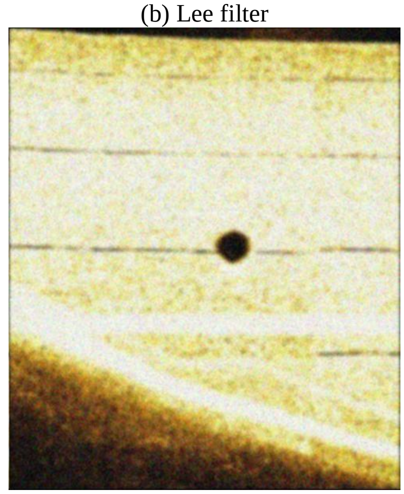


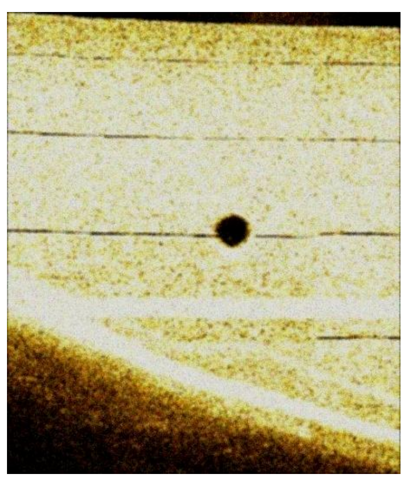
(b) Lee filter



(c) Frost filter



(d) Kuan filter



(e) Proposed algorithm

**Fig. 5. Hole on the wall of a floodgate.**