SEPD Technique for Removal of Salt and Pepper Noise in Digital Images

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Abstract *- The Salt and Pepper noise also called impulse noise is caused by sharp, sudden disturbances in the image signal. Its appearance is randomly scattered white or black (or both) pixels over the image. The principal source of impulse noise in digital image arises during image acquisition and transmission. In this paper, an efficient VLSI implementation for removing impulse noise is presented. Our extensive experimental results show that the proposed technique preserves the edge features and obtains excellent performances in terms of quantitative evaluation and visual quality. The design requires only low computational complexity and two line memory buffers. It's hardware cost is quite low. Compared with previous VLSI implementations, our design achieves better image quality with less hardware cost.*

Keywords**: *Image denoising, impulse noise, VLSI, two line buffer, SEPD.***

1. INTRODUCTION

Applications such as printing skills, medical imaging, scanning techniques, and image segmentation, and face recognition, images are often corrupted by noise in the process of image acquisition and transmission. Hence, an efficient denoising technique is very important for the image processing applications. Digital image processing has many significant advantages over analog image processing. Image processing allows a much wider range of algorithms to be applied to the input data and can avoid problems such as the build-up of noise and signal distortion during processing of images. Image noise is the random variation of brightness or color information in images produced by the sensor and circuitry of a scanner or digital camera. Image noise can also originate in film grain and in the unavoidable shot noise of an ideal photon detector. The types of noises are amplifier noise (Gaussian noise), salt-and-pepper noise, shot noise (Poisson noise), speckle noise. The paper is mainly considered with removal of fixed value impulse noise. Impulse noise also called as salt and pepper noise occurs during image acquisition in an image containing salt-and-pepper noise will have dark pixels in bright regions and bright pixels in dark regions i.e, during analog to digital conversion and in bit transmission. For an 8-bit digital image, the impulse noise which occurs as bright spots over dark background and dark spots over bright background takes a value of 0 and 255 i.e., the minimum and maximum value in the grey scale. Hence an efficient denoising technique is required for denoising. The paper proposes efficient impulse noise removal architecture with less computation complexity. For real-time embedded applications, the VLSI implementation of switching median filter for impulse noise removal is necessary and should be considered. For Customers, cost is usually the most important issue while choosing consumer electronic products. We hope to focus on low-cost denoising implementation in this paper .The cost of VLSI implementation depends mainly on the required memory and computational complexity. Hence, less memory and few operations are necessary for a low-cost denoising implementation. Based on these two factors, a simple edge- preserved denoising technique (SEPD) and its VLSI implementation for removing fixed-value impulse noise are presented. The storage space needed for SEPD is two line buffers rather than a full frame buffer. Only simple arithmetic operations, such as addition and subtraction, are used in SEPD.

II. IMPULSE NOISE REMOVAL METHODS

Over the years, better noise removal methods with different kinds of noise detectors have been proposed. Several non linear filters have been proposed for the restoration of images corrupted with impulse noise. There is a need to develop a filter which are not only effective in removing impulse noise but also preserve the edges or high frequency area of image. Therefore the use of nonlinear filtering techniques came into existence and a class of widely used non-linear digital filters is median filters and morphological filters. In [8], Zhang and Karim proposed a new impulse detector (NID) for switching median filter. NID used the minimum absolute value of four convolutions which are obtained by using 1-D Laplacian operators to detect noisy pixels. A method named as differential rank impulse detector (DRID) is presented in [9]. The impulse detector of DRID is based on a comparison of signal samples within a narrow rank window by both rank and absolute value. In Luo proposed a method which can efficiently remove the impulse noise (ERIN) based on simple fuzzy impulse detection technique. An alpha-trimmed mean based method (ATMBM) was presented in [10]. It used the alpha trimmed mean in impulse detection and replaced the noisy pixel value by a linear combination of its original value and the median of its local window. In [11], a decision-based algorithm (DBA) is proposed to remove the corrupted pixel by the median or by its neighboring pixel value according the proposed decisions. One of the most popular method is the median filter, which can suppress noise with high computational efficiency [2]. However, since every pixel in the image is replaced by the median value in its neighborhood, the median filter often removes desirable details in the image and blurs it too. The weighted median filter [3] and the center- weighted median filter[4] were proposed as remedy to improve the median filter by giving more weight to some selected pixels in the filtering window. Although these two filters can preserve more details than the median filter, they are still implemented uniformly across the image without considering whether the current pixel is noise-free or not. Adaptive filters can simultaneously suppress impulses, additive white noise, and signal-dependent noise. It is noticed that the adaptive filter is not effective in suppressing impulse noise [5-6]. To avoid the damage on noise-free pixels, the switching median filters [7] are used which consists of two steps: 1) Impulse detection and 2) Noise filtering. It locates the noisy pixels with an impulse detector, and then filters them rather than the whole pixels of an image to avoid the damage on noise-free pixel The rest of this paper is organized as follows. The proposed SEPD and the VLSI implementation of SEPD is described in section III. The Experimental Results is provided in Section IV. Conclusion is presented in Section V.

III. PROPSED SEPD

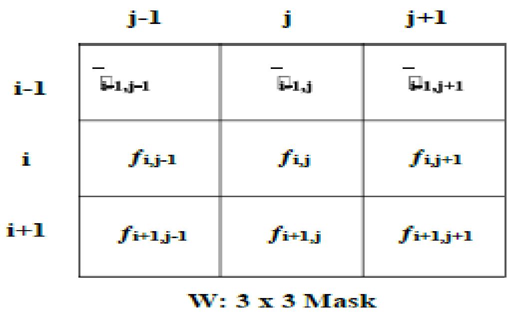
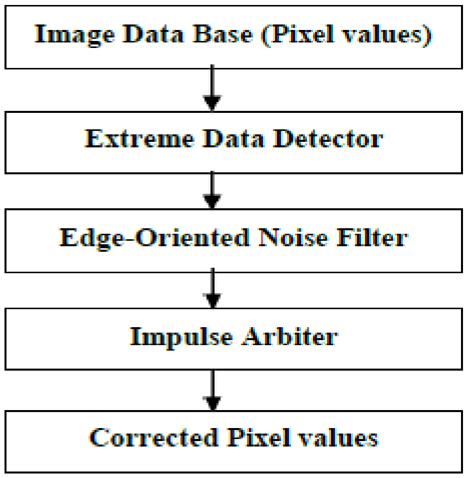


Fig.1. 3 x 3 Mask Centered on pi,j

In this method it is assumed that the current pixel to be denoised is located at coordinate (i,j) and denoted as $p_{i,j}$ and its luminance values before and after the denoising process are represented as $f_{i,j}$ and $\hat{f}_{i,j}$ respectively. If $p_{i,j}$ is corrupted by the fixed-value impulse noise, its luminance value will jump to be the minimum or maximum value in gray scale. In SEPD technique a 3 x 3 mask W centering is adopted for image denoising as shown in Fig.1. In the current W, the three denoised values at coordinates (i-1,j-1),(i-1,j) and (i-1,j+1) are determined at the previous denoising process, and the six pixels at coordinates (i,j-1),(i,j), (i,j+1), (i+1,j-1), (i+1,j) and (i+1,j+1) are not denoised yet, as shown in Fig.1. Using the 3 x 3 values in W, it will determine whether $p_{i,j}$ is a noisy pixel or not. If positive, SEPD locates a directional edge existing in W and uses it to determine the reconstructed value $\hat{f}_{i,j}$ otherwise $\hat{f}_{i,j}=f_{i,j}$.

SEPD is composed of three components: Extreme data detector, Edge-oriented noise filter and Impulse arbiter. The extreme data detector detects the minimum and maximum luminance values in W, and determines whether the luminance values of and its five neighboring pixels are equal to the extreme data. By observing the spatial correlation, the edge- oriented noise filter pinpoints a directional edge and uses it to generate the estimated value of current pixel. Finally, the impulse arbiter brings out the proper result. The Flow chart is as shown in the below Fig.2. Image Data Base (Pixel Values of the image) is extracted by using imread command in Matlab and those Pixel Values are given in Set of 3 x 3 mask for processing to the SEPD architecture. The three components of SEPD are described in detail in the following subsections.

Fig.2. Flow Chart



A). EXTREME DATA DETECTOR

The extreme data detector detects the minimum and maximum luminance values (MINinW and MAXinW) in those processed masks from the first one to the current one in the image. If a pixel is corrupted by the fixed-value impulse noise, its luminance value will jump to be the minimum or maximum value in gray scale. If $f_{i,j}$ is not equal to MINinW/ MAXinW, it is concluded that $p_{i,j}$ is a noise-free pixel and the following steps for denoising $p_{i,j}$ are skipped. If $f_{i,j}$ is equal to MINinW or MAXinW, we set the variable φ to 1, to check whether its five neighboring pixels are equal to the extreme data, and store the binary compared results into B as can also be seen in the pseudo code in Fig.6.

B). EDGE-ORIENTED NOISE FILTER

To locate the edge existed in the current W, a simple edge catching technique which can be realized easily with VLSI circuit is adopted. To decide the edge, 12 directional differences, from D1 to D12 are considered as shown in Fig.3.Only those composed of noise-free pixels are taken into account to avoid possible misdetection. If a bit in B is equal to

1, it means that the pixel related to the binary flag is suspected to be a noisy pixel. Directions passing through the suspected pixels are discarded to reduce misdetection. In each condition, at most four directions are chosen for low-cost hardware implementation. If there appear over four directions, only four of them are chose according to the variation in angle. Fig.4. shows the mapping table between B and the chosen directions adopted in the design. Since five neighboring pixels are considered 32 combinations are taken in account for denoising process.

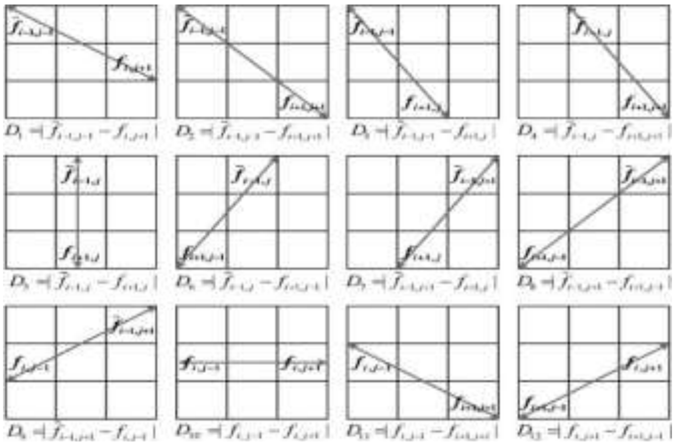


Fig.3. Twelve directional differences of SEPD

B	The chosen directions
00000	D2, D5, D8, D10
00001	D3, D5, D8, D10
00010	D2, D8, D10, D12
00011	D1, D6, D8, D10
00100	D2, D5, D7, D10
00101	D3, D5, D7, D10
00110	D2, D4, D9, D10
00111	D1, D9, D10
01000	D2, D5, D8, D11
01001	D3, D5, D7, D9
01010	D2, D6, D8, D11
01011	D6, D8, D9
01100	D2, D5, D9, D11
01101	D3, D5, D9
01110	D2, D4, D9, D11
01111	D9
10000	D2, D5, D8, D12
10001	D1, D5, D8, D12
10010	D2, D4, D8, D12
10011	D1, D6, D8, D12
10100	D1, D2, D5, D7
10101	D1, D5, D7
10110	D1, D2, D4
10111	D1
11000	D1, D5, D6, D8
11001	D3, D5, D6, D8
11010	D2, D4, D6, D8
11011	D6, D8
11100	D2, D4, D5, D7
11101	D3, D5, D7
11110	D2, D4
11111	N/A

Fig.4. Thirty-two possible values of B and their corresponding directions in SEPD.

If pi,j-1, pi,j+1, p1+1,j-1,pi+1,j and pi+1,j+1 are all suspected to be noisy pixels (B=" 11111") , no edge can be processed, so i,j(the estimated value of) is equal to the weighted average of luminance values of three previously denoised pixels and calculated as (i -1,j-1+2xi -1,j+ i -1,j+1)/4. In other conditions except when B ="11111" the edge filter calculates the directional differences of the chosen directions and locates the smallest one (Dmin) among them. The smallest directional difference implies that it has the strongest spatial relation with pi,j, and probably there exists an edge in its direction. Hence, the mean of luminance values of the two pixels which possess the smallest directional difference is treated as i,j. For example, if B is equal to "10011," it means that fi,j-1 , fi+1,j and fi+1,j+1 are suspected to be noisy values. Therefore, D2-D5, D7and D9-D11 are discarded because they contain those suspected pixels (see fig.3) The four chosen directional differences are D1, D6, D8 and D12 (see Fig.4). Finally is equal to the mean of luminance values of the two pixels which possess the smallest directional difference among D1, D6, D8 and D12.

C). IMPULSE ARBITER

Since the value of a pixel corrupted by the fixed-value impulse noise will jump to be the minimum/maximum value in gray scale, it is concluded that pi,j is corrupted, fi,j is equal to MINinW or MAXinW . However, the converse is not true. in cases where the pixel might not be corrupted by fixed value impulse noise but might be in the region of minimum or maximum luminance i.e., the minimum or maximum value in W might be identified as a noisy pixel. In order, to avoid the possible misdetection of pixel an impulse arbiter with spatial threshold is proposed. Since, threshold is an important consideration in any system an appropriate threshold can produce better result. If pi,j is a noise-free pixel and the current mask has high spatial correlation, fi,j should be close to and |fi,j -𝑓 i,j| is small. That is to say, pi,j might be a noise-free pixel but the pixel value is MINinW or MAXinW if |fi,j-𝑓 i,j | is small. |fi,j -𝑓 i,j| is measured and compared it with a threshold to determine whether is corrupted or not. The threshold, denoted as Ts, is a predefined value. If pi,j is judged as a corrupted pixel, the reconstructed luminance value 𝑓i,j is equal to 𝑓 i,j; otherwise; 𝑓i,j=fi,j. However, it is not easy to derive an optimal threshold through analytic formulation If the threshold value is greater than the difference, then the denoised value is taken as the reconstructed value else the original value is retained.

The output of the impulse arbiter is fed back as feedback to the first stage, to process other pixels as seen in Block diagram (Fig.5). The corrected pixel value is given back to the line buffers through mux, so that according to the position of the pixels it is given to even or odd buffers and through mux it is replaced in the register bank. A new set of pixel values is fed to the extreme data detector and the process continues to obtain a noise-free image.

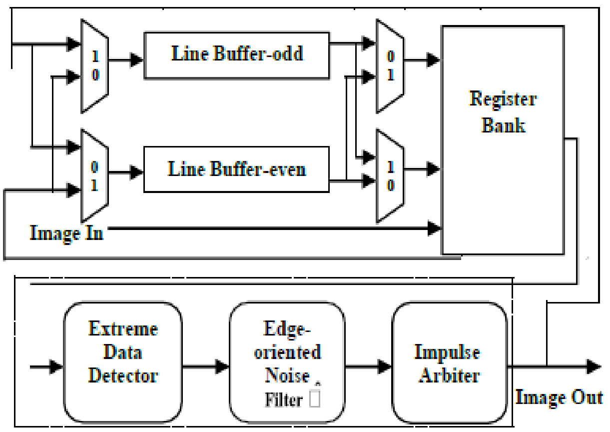


Fig.5.Block Diagram of VLSI Architecture for SEPD

/*Input image size : row(height) x col(width)*/ if
for(i = 0; i < row; i = i+1)
{
for(j = 0; j < col; j = j+1)
{
/*Extreme data detector*/
Get W, the 3 x 3 mask centered on (i,j); Find MINinW and MAXinW;
/*the minimum and maximum values from the first W to the current W*/
φ=0; /*initial values*/
if ((fi,j = MINinW) or (fi,j=MAXinW))
φ=1; /* pi,j is suspected to be a noisy pixel*/ if (φ=0)
{ i.j=fi,j; break;} /* pi,j is a noisy-free pixel*/ B=b1b2b3b4b5="00000"; /*initial values*/ If ((fi,j-1=MINinW)or(fi,j-1=MAXinW))
b1=1; /*pi,j-1 is suspected to be a noisy pixel*/ if ((fi,j+1=MINinW)or(fi,j+1=MAXinW))
b2=1; /*pi,j+1 is suspected to be a noisy pixel*/ if ((fi+1,j-1=MINinW)or(fi+1,j-1=MAXinW))
b3=1; /*pi+1,j-1 is suspected to be a noisy pixel*/ if ((fi+1,j=MINinW)or(fi+1,j=MAXinW))
b4=1; /*pi+1,j is suspected to be a noisy pixel*/ if ((fi+1,j+1=MINinW)or(fi+1,j+1=MAXinW))
b5=1; /*pi+1,j+1 is suspected to be a noisy pixel*/
/*Edge-Oriented Noise Filter*/
Use B to determine the chosen directions across pi,j according to fig,4;
if (B="11111")
/*no edge is considered*/
□i,j=(□i -1,j-1 + 2x□i -1,j +□i -1,j+1)/4; else
{ find Dmin (the smallest directional difference among the chosen directions);
□i,j=the mean of luminous value of the two pixels which own Dmin;}

/*Impulse Arbiter*/
if (|fi,j-□i,j| > Ts)
□i,j=□i,j; /*pi,j is judged as noisy pixel*/ else
□i,j=fi,j; /*pi,j is judged as noisy-free pixel*/
}
}

IV. EXPERIMENTAL RESULTS

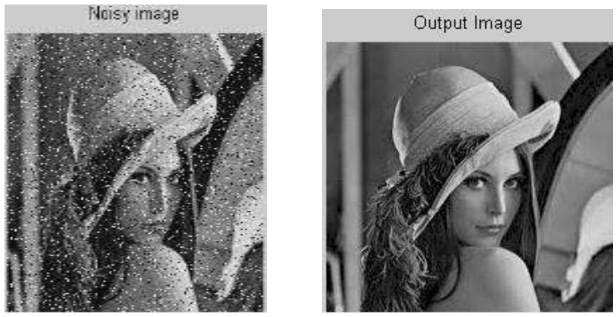
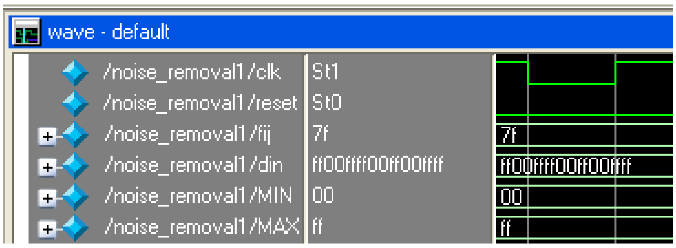


Fig.6.Pseudo Code for SEPD Technique

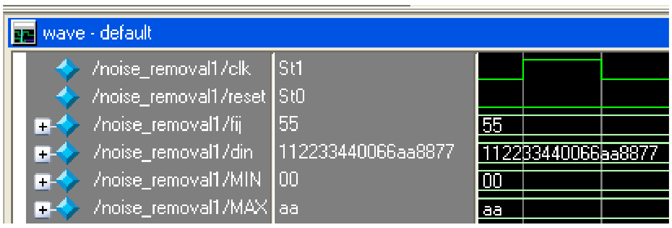
The PSNR(Peak signal to noise ratio) of the above image by using SEPD technique is 35.16 and MSE(mean square error) is 19.818.The Simulation Results obtained using Model Sim for Verilog coding ,for the above SEPD technique is as follows:

1).When all the pixels including Pi,j in W:3X3 mask are noisy,(B="11111").



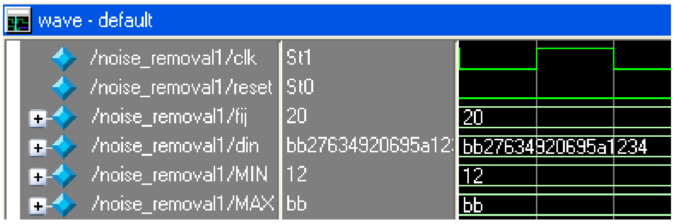
2).When pi,j is noisy ,for any condition of B.

(Eg. shown is for B="01100")



3).When pi,j is not noisy ,for any condition of B.

(Eg. shown is for B="00000")



V. CONCLUSIONS

By the implementation of the proposed algorithm described in this paper, it is possible to suppress the impulse noise in an efficient way by retaining the original image's fine details. It requires less memory and few operations and achieves excellent performance in terms of quantitative evaluation and

visual quality even if the noise ratio is high. By which this method will reduce the hardware cost and computational complexity, thus helpful for any real-time embedded applications. It provides higher filtering quality and better performance than the existing techniques. The architectures work with monochromatic images, but they can be extended for working with RGB color images and videos.

REFERENCES

[1] W. K. Pratt, Digital Image Processing. New York: Wiley-Inter-science, 1991.

[2]T. Nodes and N. Gallagher, "Median filters: Some

modifications and their properties," IEEE Trans. Acoust., Speech, Signal Process., vol.ASSP-30, no. 5, pp. 739–746, Oct. 1982.

[3] D. R. K. Brownrigg, "The weighted median filter," Comm. ACM, vol. 27, pp. 807-818, Aug. 1984.

[4] S.-J. Ko and Y.-H. Lee, "Center weighted median filters and their applications to image enhancement," IEEE Trans. Circuits Syst., vol. 38, no. 9, pp. 984–993, Sep. 1991.

[5] H. Hwang and R. Haddad, "Adaptive median filters: New algorithms and results," IEEE Trans. Image Process., vol. 4, no. 4, pp. 499–502, Apr. 1995.

[6] I. Andreadis and G. Louverdis, "Real-time adaptive image impulse noise suppression," IEEE Trans. Instrum. Meas., vol. 53, no. 3, pp. 798–806, Jun. 2004.

[7] Rajoo pandey,"An improved Switching Median Filter for Uniformly Distributed Impulse Noise removal," World Academy of Science, Engineering and technology ,2008.

[8] S. Zhang and M. A. Karim, "A new impulse detector for switching median filter," IEEE Signal Process. Lett., vol. 9,no. 11, pp. 360–363, Nov. 2002.

[9] I. Aizenberg and C. Butakoff, "Effective impulse detector xbased on rank-order criteria," IEEE Signal Process. Lett., vol. 11, no. 3, pp. 363–366, Mar. 2004.

[10] Manjunath M, Dr H B Kulkarni "Analysis of Unimodal and Multimodal Biometric System using Iris and Fingerprint" Perspectives in Communication, Embedded-Systems and Signal-Processing (PiCES) – An International Journal ISSN: 2566-932X, Vol. 2, Issue 8, November 2018.

[11] W. Luo, "Efficient removal of impulse noise from digital images," IEEE Trans. Consum. Electron., vol. 52, no. 2, pp. 523–527, May 2006.

[12] W. Luo, "An efficient detail-preserving approach for removing impulse noise in images," IEEE Signal Process. Lett., vol. 13, no.7, pp.413–416, Jul. 2006.

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