An Efficient DTBDM in VLSI for the Removal of Salt-and-Pepper Noise in Images Using Median filter

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***Abstract*— During the process of signal acquisition and transmission images might be affected by impulse noise. An efficient de-noising scheme is designed for the removal of fixed valued impulse noise. The present technique consists of decision-tree–based impulse noise detector is used to detect the noisy pixels and a median filter to reconstruct the noisy pixel intensity values. The experimental result shows that the median filter is found to be the best for the removal of impulse noise. The design requires only low components in its architecture and preserves the quality of the image and reduces the delay. Its hardware cost is low and suitable to many real time applications.**

Keywords*— *Fixed valued impulse noise, Gray scale images, Image de-noising, Impulse detector, Median filter

I. INTRODUCTION

Images are often corrupted by impulse noise due to noise generated in noisy sensors, electronic equipments, and communication channels or due to bit transmission errors. Impulse Noise is one type of such commonly occurred noise during the transmission and acquisition of the images. The noise means an unwanted signal or unwanted electrical fluctuations in signals. The noises are classified into two main categories Dependent Noise and Independent Noise. The independent noise is also called salt and pepper noise of impulse noise. The impulse noises in images have been divided into two main categories fixed valued impulse noise and random valued impulse noise in images.

The fixed valued impulse noise is also called salt and pepper noise. This impulse noise in images may seriously effects the image qualities. In gray scale images each element has an assigned intensity values which ranges from 0 to 255. In salt and pepper noise the pixel values of a noisy pixel is either maximum or minimum in its gray scale. The noisy pixel values in Random valued impulse noise are uniformly distributed in the range [0,255] for gray scale images. There have been many techniques for the removal of salt and pepper noise and some of the techniques perform very well [1].[2],[3]. The noisy images cannot be transmitted or can't be used for any image processing applications [4], such as medical imaging, scanning techniques, license plate recognition, face recognition, and so on. A better noise removing technique is introduced to remove the noise in images by preserving the image details.

For the impulse noise suppression many methods have been proposed in image processing. The standard median filter [5] is such technique for the removal of image impulse noise. This technique has the disadvantage of poor image quality obtained after the de-noising. This might blur te image because it modifies both the noisy and noisy free pixels. In order to overcome this disadvantage of standard median filter new technique switching median filter have been introduced. The witching median filter consists of two main steps an impulse detector to detect the noisy pixels and an impulse noise filter filters the noisy pixels. The advantage of this technique is that it effectively removes the noisy pixels only rather than the whole pixels of the image to avoid causing damage on noisy-free pixels. Luo proposed another technique An Alpha Trimmed Mean Based Method (ATMBM) [6]. It uses alpha trimmed mean for impulse noise detection and the detected noisy pixel values is replaced by the original detected value and the median value of its local window. A Differential Rank Impulse Detector (DRID) was presented in [7]. In DRID impulse detector works on the comparison of signal samples within a narrow rank window by considering both rank and absolute values.

Based on the complexity the de-noising techniques have been classified into lower complexity [8],[9] and higher complexity technique [10],[11] The lower complexity technique provides a good quality for the reconstructed image .In the field of VLSI reduction of chip area is found to be one important criteria and the new de-noising technique provides customer satisfaction. Hence a new de-noising technique decision tree based de-noising method (DTBDM) using median filter is introduced for the removal of salt and pepper noise in images. The decision tree is a simple but powerful tool for the complex multivariable analysis. It can breakdown a complex decision making process into simpler one and finds better solution for the problem. To enhance the effects of removal of impulse noise the reconstructed pixels have been written back as a part of input data

II. PROPOSED ALGORITHM

The image de-noising technique consists of two components Decision Tree Based Impulse Detector and an impulse noise filter here used is Median filter. The Median filter is the best filter for the removal of Impulse noise because this filter preserves the edge details in the image. The corrupted image applying to the decision tree based de-noising method is gray scale image corrupted by fixed valued impulse noise. Consider a 3×3 Mask for the image de-noising. The eight pixel values in the Mask M are divided into two sets of equal in number.

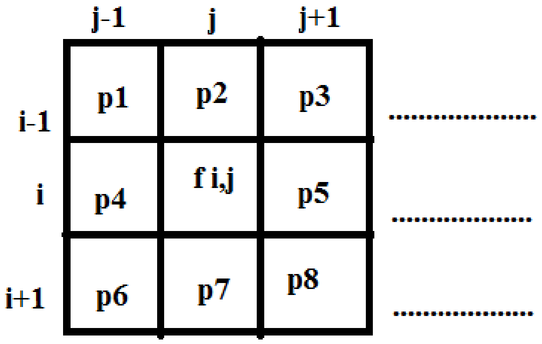

Fig.1 *Noisy pixel centered on 3×3 Mask*

Mask top half = {p1,p2,p3,p4} (1)
Mask bottom half = {p5,p6,p7,p8} (2)

Let p i,j be the noisy pixel is located at the coordinate i,j and having pixel value y i,j and f i,j its luminance value. Each pixel has its corresponding luminance values. This 3×3 Mask is the input for the image de-noising process. The decision tree based impulse detector detects each pixel in the 3×3 Mask ad its correlation between the adjacent pixels. The eight pixels in the 3×3 Mask have been divided into two sets of equal intensities Mask top half and Mask bottom half. During the scanning process the decision tree based Impulse detector scans each 3×3 Mask in corresponding rows of the image pixels. These pixel values are temporarily stored in register bank during the scanning process. The pipelined process sends the processed pixels back to the register bank. The algorithm checks the noisy pixel by scanning each and every pixel of rows and columns of the images using pipelining concept. If the result of the impulse detector is true then that corresponding pixel values are filtered using Median filter. The median filter reconstructs that noisy pixel value by a new value and is written back as a part of the input image pixels.

The data flow of Decision Tree Based De-noising process is as follows

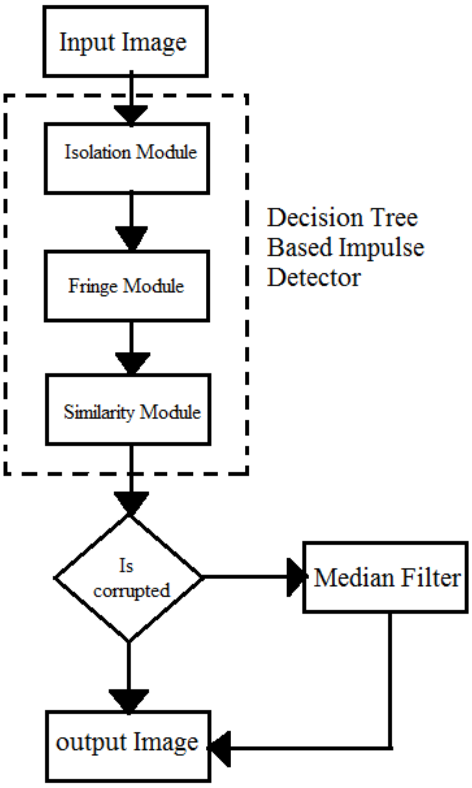

Fig. 2. The data flow of de-noising process

The algorithm checks the noisy pixel by scanning each and every pixel of rows and columns of the images using pipelining concept. The advantage of the present technique is the presence of the decision tree based impulse detector than the previous de-noising techniques. The first step is the checking of each pixel values by the impulse detector. If the result of the impulse detector is true then that corresponding pixel values are filtered using Median filter. The median filter reconstructs that noisy pixel value by a new value and is written back as a part of the input image pixels.

III. VLSI IMPLEMENTATION OF DECISION TREE BASED DE-NOISING METHOD

The input image for the de-noising process is stored in SRAM. For improving image quality an adaptive technology is used. As the part of this technology the reconstructed pixel values have been written back to the input pixels. The architecture in VLSI of DTBDM consists of Line buffer, Register bank, decision tree based impulse detector and Median filter .In VLSI the digital images cannot be processed directly. The performance of the present de-noising technique can be increased by pipelined architecture.

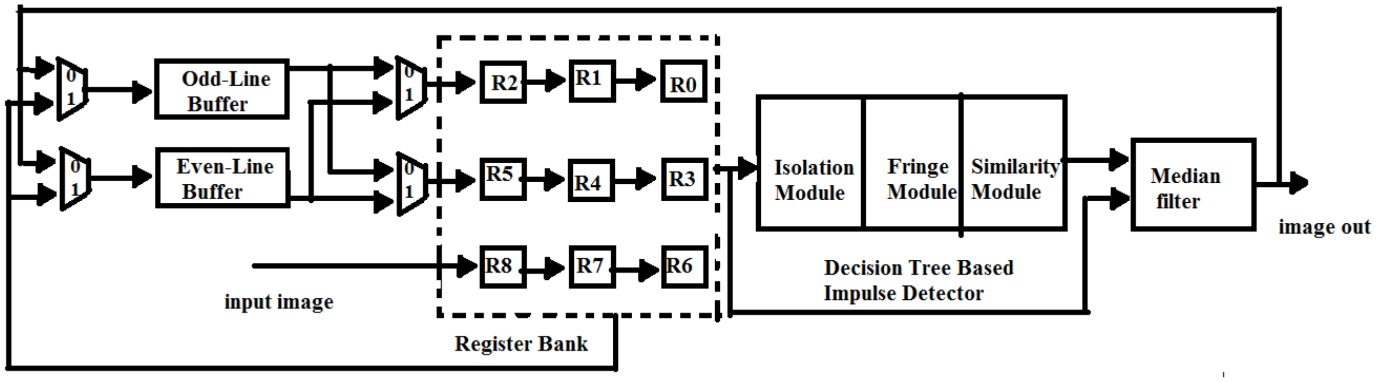

Fig. 3. VLSI architecture of Decision Tree Based De-noising method

A. Line Buffer

Three scanning lines are needed for a 3×3 Mask in DTBDM technology. For processing the noisy pixel p i,j three rows of the 3×3 Mask IS considered. Line buffer consists of an even line buffer, odd line buffer and four cross coupled multiplexers. The even and odd line buffers are used to store the pixels in corresponding even and odd rows. To achieve a low cost and reduced power consumption at the time of implementation line buffer is implemented in dual port SRAM

B. Register bank

The register bank is designed to store the pixel values of the 3×3 Mask for temporarily. The de-noised pixels values after filtering through Median filter is feedback back to the register banks for processing

C. Decision tree based impulse detector

The decision tree based impulse detector is used to detect the noisy pixels in an image. The impulse detector checks each pixel in rows and columns of the image and their relation with the neighbouring pixels. It is a complex decision making process. The impulse detector finds solution for the multivariable problem by dividing the complex tasks into simpler problems and finds a unique solution for the problem. For that purpose impulse detector having three modules .Isolation Module, Fringe Module, Similarity Module

- ***Isolation Module***

The isolation Module is used to determine the smoothness of the image. The property smoothness of the image determines that the image is not noisy or not on edge. If the result of the isolation module is positive, then the current pixel is noisy or edge and if the result is negative the current pixel is not noisy or edge.

- ***Fringe Module***

Fringe module is used to check whether the image is on the edge or not. The pixel situated on the edge having considerable change in the pixel value when compared with its neigh boring pixels. The pixels values corrupted by impulse noise have considerable change in the pixels values than the normal one. The fringe module has to be properly designed to determine the current pixel is on edge or corrupted by noise. The eight possible directions are taken in the 3×3 Mask and determines the absolute values of pixel differences from the eight possible directions of the 3×3 Mask. The absolute differences of the pixels in each eight possible directions of provided Mask are compared with the threshold values.

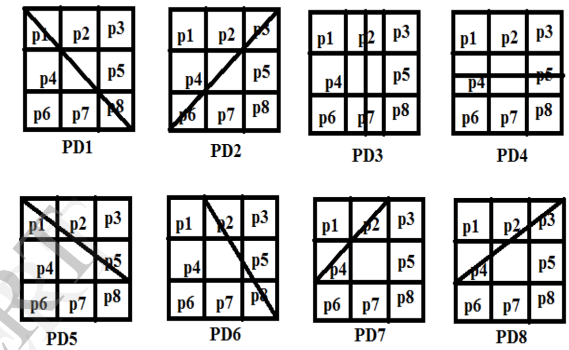

Fig.4. Eight directions in DTBDM

If the decision of the fringe module is negative then the pixels is on edge and if it is true then it is a noisy pixel. The process will enter into next stage only for the true condition. Then the noisy pixel values are reconstructed by the median filter. The pixels on edge will not go for image filtering process

- ***Similarity Module***

Similarity module is the last module. The similarity module is used to confirm the result, the nine values in the 3×3 Mask is sorted in ascending pixel values, the fourth; fifth, sixth values in the mask M are taken for computing the maximum and minimum pixel values. The current pixel value fi,j if it is not in between maximum and minimum values the pixel p i,j is considered to be noisy pixel.

D. Median filter

The median filter is suitable for the removal of impulse noise. In this image filtering technique for preserving the edge details of the image the average of pixels having minimal spatial distance is considered before taking the median. The average values of the pixels having minimal directional difference are considered for calculation. The directional differences of the pixels having minimum spatial distance is considered

The four directions can be computed as follows

$$DD1 = |p2 - p7| * 2$$

$$DD2 = |p4 - p5| * 2 \quad (3)$$

$$DD3 = |p1 - p8| * 2$$

$$DD4 = |p3 - p6| * 2$$

The average values can be computed as follows

$$f\hat{}i,j = \begin{cases} \frac{p2+p7}{2}, if\ Dmin = DD1 \\ \frac{p4+p5}{2}, if\ Dmin = DD2 \\ \frac{p1+p8}{2}, if\ Dmin = DD3 \\ \frac{p3+p6}{2}, if\ Dmin = DD4 \end{cases} \quad (4)$$

Then the median of four pixel values can be determined as

$$\bar{f}_{i,j} = Median(\hat{f}_{i,j}, p2, p4, p5, p7) \quad (5)$$

IV. EXPERIMENTAL RESULTS

To verify the characteristics and performance of various de-noising algorithm a variety of test images are available Lena, peppers. Consider the test image Lena and by applying in MATLAB environment fixed valued impulse noise of varying intensities can be introduced. The various simulations are carried out in well known 8bit gray scale Lena Images .In the simulation the images taken are corrupted by impulse noise. The digital gray scale image taken here cannot process in VLSI directly. The image is converted to its corresponding pixel values and is fed to the de-noising process. The proposed Decision Tree Based De-noising Method in VLSI is designed using VHDL.MODEL SIM is used for the simulation. The synthesis can be performed in Xilinx SPARTON 6 and obtained the synthesis result. The synthesis result shows that the current technique decision tree based de-noising method using median filter have reduced consumption of the chip area. Hence the cost of implementation is less in the present technique. The simulation results is as follows

(a)Original Image

(b) Noisy Image

(c) Processed Image

Fig.5.Result of DTBDM in VLSI

The synthesis result obtained using Xilinx Sparton 6 platform and the synthesis result for this decision tree based de-noising method is shown in the table below.

TABLE 1
Comparisons of synthesis result of DTBDM using edge preserving image filter and median filter

DEVICE UTILIZATION SUMMARY (ESTIMATED VALUES)				
Methods	**DTBDM using edge preserving image filter**		**DTBDM using median filter**	
Logic Utilization	***Used***	***Available***	***Used***	***Available***
No of Slice LUTs	2951	9112	2904	9112
No of fully used LUT-FF pairs	17	2958	17	2958
No of bounded IOBs	81	232	81	232
No of Slice Registers	144	18224	24	18224
No of BUFG/BUFGCONTROL	1	16	1	16

TABLE 2
Comparisons of PSNR (dB) of images corrupted by fixed valued impulse noise

Methods	**5% Noise**	**10% Noise**	**15% Noise**	**20% Noise**
Edge preserving Image filter	33.192	32.53	31.125	30.9513
Median filter	40.319	37.24	35.472	34.0762

The table above shows the comparison of PSNR values of the image reconstructed by decision tree based de-noising method using edge preserving image filter and median filter.
For the experimental analysis fixed valued impulse noise of varying percentage is added to the images. The comparison results shows that the present de-noising technique using median filter have better PSNR values than the previous technique

V. CONCLUSION

In this paper an efficient decision tree based de-noising method is designed using VLSI. The approach uses a decision tree based impulse detector for detecting the noisy pixels and a median filter for the reconstruction of the noisy pixel intensities. This technique provides better removal of impulse noise by median filter and requires less computational time. The implementation results show the images obtained after de-noising in the present technique have excellent image quality by preserving the image details. The main advantage of this approach is that the hardware required is less and hence the cost is low

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