International Journal of Future Generation Communication and Networking
Vol.14, No. 1, (2021), pp. 4438 - 4443

An Efficient VLSI Architecture For Removal Of Impulse Noise In The Image Using Edge Preserving Filter

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Abstract

Impulse noise is a common cause of image corruption during image processing and transmission procedures. To achieve low-complexity VLSI architecture, we propose An Efficient VLSI Architecture for Removal of Impulse Noise in Images Using Edge Preserving Filters in this paper. To detect the noisy pixels, we use a decision-tree-based impulse noise detector, as well as an edge-preserving filter. To recreate the intensity values of noisy pixels, an edge-preserving filter and a mathematical morphological filter were used, as well as an edge-preserving filter and a mathematical morphological filter. In addition, adaptive technology is used to boost the effects of removing random valued impulse noise. In terms of both quantitative assessment and visual efficiency, our proposed methodology outperforms the previous lower-complexity approaches. Furthermore, the results could be equivalent to those of higher-complexity methods. Using TSMC 0.18m technology, the VLSI architecture of our design achieves a processing rate of around 200 MHz the architecture only needs two-line memory buffers and has a low computational complexity. It has a low hardware cost and can be used in a variety of real-time applications.

Keywords*— Spartan 6kit (FPGA), Xilinx ISE, edge-preserving filter, VLSI Architecture, Denoising, Morphological filter.*

I. INTRODUCTION

In the process of acquiring photos and transmitting media through various channels, impulse noise is commonly included in photographs. While image processing is critical in a variety of sectors, noise has a significant impact on the process' performance. The noise may have a significant impact on image processing algorithms' performance. As a result, effective denoising becomes a critical challenge in image processing. Impulse noise is divided into two types based on the distribution of noisy pixel values: fixed-valued impulse noise and random-valued impulse noise. Because the pixel value of a noisy pixel is either the minimum or highest value in grayscale images, the former is also known as salt-and-pepper noise. For grey-scale photographs, the values of noisy pixels damaged by random-valued impulse noise are evenly distributed in the range [0, 255]. There have been several techniques for reducing salt-and-pepper sounds, and some of them have shown to be effective. Due to

ISSN: 2233-7853 IJFGCN

the unpredictable distribution of noisy pixel values, random-valued impulse noise is more challenging to manage. In this project, we simply focus on eliminating random-valued impulse noise from the damaged image. We're presenting a method for removing noise from photos. Although several filters such as the mean filter, median filter, Gaussian filter, and others are already in use, they are useless in that they affect both noiseless and noisy pixels. This might lead to a misunderstanding of the information contained in the picture. The alpha-trimmed mean filter will be used. This filter is a cross between a mean and a median filter. This filter overcomes the disadvantage of the mean filter, which is that it alters the values of both noiseless and noisy pixels since it is unable to discriminate between them. We use an edge preserving filter in addition to the alpha trimmed mean filter. Using standard filters may result in the loss of picture edges, or in other words, edges may become blurred. We'll be able to avoid this with the help of an edge-preserving filter. A decision tree-based denoising approach is used to discern between different sections of a picture, such as a smooth region and an edge region. The decision tree-based impulse detector in this DTBDM will detect the noisy pixels based on the region they are in.

II. LITERATURE SURVEY

The authors of this recent paper [1] tells us that by utilizing the modules such as, ‘isolation module’, ‘fringe module’ and ‘similarity module’, the denoising is done quite effectively and the proposed edge preserving filter is used to preserve the edges in the image Using FPGA Mechanisms to Implement NLM for Denoising of MRI Images [2] The have worked to propose that a denoising method based on Non-local Mean filter and has compared it with Anisotropic Diffusion filter. The ADF smooth the images by blurring them like Gaussian filter but the effect is, unlike Gaussian, blurring of edges is much less and the features of the image are clearly visible. But it doesn’t preserve the edge. Hence they have used NLM filter to solve this problem. In [3] they have proposed the work to tell us about an edge preserving filter in this paper. They have designed an algorithm which considers pixel values along a direction in a 3x3 mask. Eight directions have been defined and if the pixel values along this direction have similar values with minor variations then that region in the image is considered as an edge. Thus edge can be preserved. Using a Combined Filter, an Efficient De-noising Architecture for Impulse Noise Removal in Color Images. [4]In this survey they have proposed that a de-noising method for color images using Adaptive Marginal Median filter. The Adaptive marginal median filter is effective in preserving details of the images and it smooth the image. Remove Impulse Noise in Medical Images Adaptively and in Real-Time. In [5] they have worked to show that the Image Histogram and Fuzzy Method and have used a Median filter to remove high noise levels in images. This method is especially effective for denoising medical images like X-rays, sonography reports, etc. This method is highly effective in removing high-level noise in medical images. [6] The alpha-trimmed mean filter is a nonlinear windowed filter that is a combination of the mean and median filters. The basic concept behind a filter is to look at the neighbourhood of any signal (image) element, discard the most atypical ones, and measure mean value using the rest. The parameter Alpha, as you can see from the filter's name, is responsible for the number of trimmed components. This filter is a combination of the Mean and Median filters, resulting in a more efficient output.

III. PROPOSED METHODOLOGY

ISSN: 2233-7853 IJFGCN

In order to determine whether pi,j is a noisy pixel, the correlations between pi,j and its neighbouring pixels are considered. Surveying these methods, we can simply classify them into several ways observing the degree of isolation at current pixel, determining whether the current pixel is on a fringe or comparing the similarity between the current pixel and its neighbouring pixels. As a result, we build three modules in our decision-tree-based impulse detector: separation, fringe, and resemblance. A decision tree is formed by concatenating the decisions of these modules. The decision tree is a binary tree that can use various equations in different modules to decide the position of pi,j. The isolation module is used first to determine if the pixel value is in a smooth field. If the result is negative, we know that the current pixel is part of the noisy free category. Otherwise, a positive outcome indicates that the present pixel is not a noisy pixel or is located on an edge. The fringe module is used to double-check the outcome. The outcome of the fringe module will be negative (noisy-free) if the current pixel is on an edge; otherwise, the result will be positive. If the isolation and fringe modules are unable to establish if the current pixel is noisy free, the resemblance module is used to determine the outcome. It measures the resemblance of the present pixel to the pixels around it. Pi,j is a noisy pixel if the answer is positive; otherwise, it is noise-free.

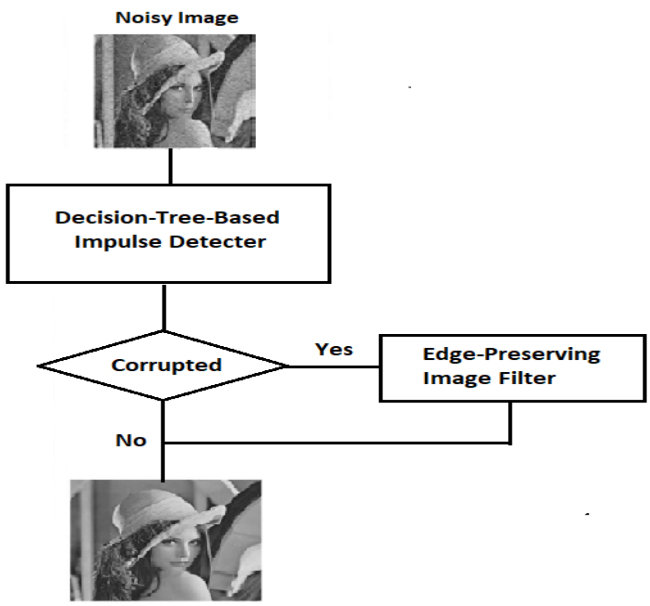

Fig. 1 The dataflow of DTBDM

IV. PROPOSED SYSTEM DESIGN

The architecture of DTBDM shown in Fig. Consists of five main blocks 1) Line buffers, 2) register bank, 3) DTBID, 4) Edge preserving image filter and 5) Controller

A. Line Buffer

DTBDM adopts a 3×3 mask, so three scanning lines are needed. Therefore mask contains 9 pixels. The centre pixel i.e. 5th pixel is processed.

B. Register Bank

It consists of nine registers to store the 3×3 pixel values of the current mask.

ISSN: 2233-7853 IJFGCN

C. Decision Tree Based Impulse Detector

The associations between the centre pixel and its neighbouring pixels in the mask are considered in order to decide if the present mask's centre pixel is noisy or not. This DTBID is made up of three modules: i) isolation module ii) fringe module and iii) similarity module.

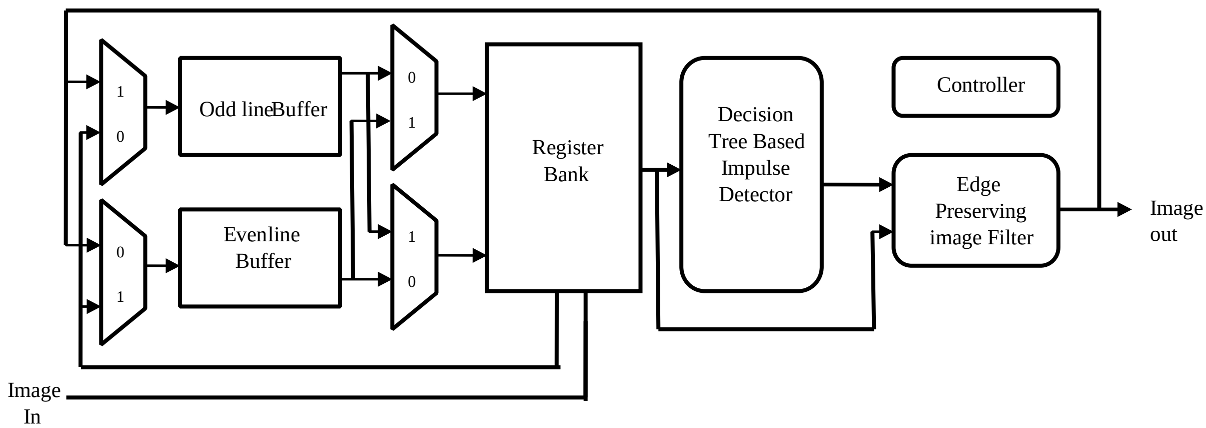

Fig.2 VLSI Architecture of de cision Tree Based Denoising Method

A decision tree is formed by concatenating the decisions of these modules. The decision tree is a binary tree that can decide if the mask's centre pixel is noisy or not. The pixel is noisy if the response is positive. Otherwise, a pixel is called noise-free if the effect is negative. The isolation module is used to determine whether or not a pixel is in the smooth area. The Fringe module is used to determine whether or not a pixel is on the fringe. Finally, if both the isolation and fringe modules fail to detect the noise, the effect is determined by the resemblance module.

D. Edge Preserving Image Filter

The noise-free pixel's pixel value remains unchanged. The Edge Preserving Image Filter is used to reconstruct the pixel value of a noisy pixel. It is made up of two modules: I the min ED generator and ii) the Average generator. Out of eight paths, the min ED generator produces the edge with the lowest weight. The value of a noisy pixel is then reconstructed using pixels in the minimum value direction. The median value is used for reconstruction of noisy pixel if all other pixels in mask are also noisy.

E. Controller

It sends control signals to control pipelining and timing statuses of the VLSI DTBDM circuit. It also sends signals to schedule reading and writing statuses of the data that are stored in register bank or in line buffers. The VLSI DTBDM involves too many architecture for detection of noise as well as for reconstruction of noisy pixel value. Which makes it very complex to realise and to use for real time applications

ISSN: 2233-7853 IJFGCN

V. RESULTS

We have used Spartan6 FPGA kit to implement VLSI architecture. For this, 512x512 8-bit greyscale corrupted image of Lena, Boat, Photographer are generated using MATLAB environment with noise ratio of 1%, 10% and 30%. These corrupted images are then denoised using our VLSI architecture, and then the denoised images are compared with original image. These comparisons are done on the basis of PSNR ratio and SSIM. Following table shows the test results:

(a) Lena with 1% ND (b) Lena with 10% ND (c) Lena with 30% ND

Fig. 3 Images of Lena with different Noise ratios

(a)PSNR-51.55, SSIM-0.9986 (b)PSNR-40.04, SSIM-0.9847 (c)PSNR-33.03, SSIM-0.9409

Fig. 4 Denoised Images of Lena with PSNR and SSIM

VI. CONCLUSION

Our method is robust and fast and has low-complexity compared with previous methods. Proposed method enhances the performance and is better than previous lower-complexity methods. It is comparable to that of high-complexity methods. The approach uses the decision tree-based detector to detect the noisy pixel and employs an effective design to locate the edge. By using alpha-trimmed mean filter, the effectiveness of impulse noise removal has greatly increased and the quality of the image is maintained. The cost of the VLSI architecture is quite low, and the speed of operation is fast.

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ISSN: 2233-7853 IJFGCN