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Performance Efficient Real Time Image Denoising Using Bilateral Filter

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***Abstract:** The bilateral filter reduces noise while preserving details. This reason we chosen bilateral filter for image denoising. The design is described on register-transfer level. This feature of the kernel-based design is supported by the arrangement of the input data into groups so that the internal clock of the design is a multiple of the pixel clock given by a targeted system. Combining these features, the bilateral filter is implemented as a highly parallelized pipeline structure with very economical and effective utilization of dedicated resources. As the original form of the bilateral filter with no approximations or modifications is implemented, the resulting image quality depends on the chosen filter parameters only. Due to the quantization of the filter coefficients, only negligible quality loss is introduced. Adding bilateral and a conditional averaging filter to improve image quality. This filter requires a single image or frame to denoise.*

***Keywords:** component; formatting; style; styling; insert (Minimum 5 to 8 key words must be phrases)*

I. Introduction

Digital images play an important role both in daily life applications such as satellite television, magnetic resonance imaging, and computed tomography as well as in areas of research and technology such as geographical information systems and astronomy. Data sets collected by image sensors are generally contaminated by noise. Imperfect instruments, problems with the data acquisition process and interfering natural phenomena can all degrade the data of interest. Furthermore, noise can be introduced by transmission errors and compression. Thus, denoising is often a necessary and the first step to be taken before the images data is analysed. It is necessary to apply an efficient denoising technique to compensate for such data corruption.

Image denoising still remains a challenge for researchers because noise removal introduces artifacts and causes blurring of the images. Noise modeling in images is greatly affected by capturing instruments, data transmission media, image quantization and discrete sources of radiation. Different algorithms are used depending on the noise model. Most of the natural images are assumed to have additive random noise which is modeled as a Gaussian. Speckle noise is observed in ultrasound images whereas Rican noise affects MRI images.

BILATERAL filtering has gained great popularity in image processing due to its capability of reducing noise while preserving the structural information of an image. The bilateral filter is technique to smooth images while preserving edges. Tomasz and Mantachie gave it, its name. The use of bilateral filtering has grown rapidly and is now ubiquitous in image-processing applications. The bilateral filter has several advantages that explain its success.

II. Bilateral Filter

The proposed method adopted the kernel based design and expensive exponential calculations in bilateral filter are get rid of by the effective usage of look-up tables. Coefficients based on Gaussian function with desired variance are pre-calculated and stored in look-up tables and invoked them, when needed. In fact, all the coefficients are floating points and lie between 0 and 1. But all are converted to integer numbers to improve the operational speed. Pixel elements in kernel are grouped by considering the Euclidean distance between each pixel and the center pixel. It increases the speed and aids to perform the multiple group operations at one pixel clock cycle. To improve the denoising capability of bilateral filter, a conditional average filter is incorporated into it, before applying the photometric component. Center pixel of the kernel is replaced by the average value of the neighboring pixels, if desired. The desired condition is that, if the value of center pixel of the kernel diverges from the neighboring pixels by a certain amount, then the conditional average filter is invoked. These the modifications produce an innovative bilateral filter with better result in image denoising without any compromise in speed.

In this chapter the details of design concepts and current status of work are presented. First the design concepts such as algorithm and flowchart for basic implementation of bilateral filter are discussed. Then design concepts for a modified bilateral filter by incorporating a conditional median filter are discussed. And then the design concepts in register transfer level for the FPGA implementation of bilateral filter and its modifications are presented using block diagrams.

I chose Euclidean distance for grouping pixels in register matrix rather than taking horizontal and vertical distances from the mid-pixel. This grouping technique gave me an idea for reducing the area of whole FPGA architecture.

Then I combined the photometric filter component and geometric filter component into a single unit. In these filter components, coefficients have stored in look up tables. They are multiplied with the image pixels in subsequent steps. So we have two kinds of coefficients stored in separate sections. What I had done while reducing structure is that, I pre-calculated those coefficients separately and multiplied them together, then scaled by factor 255, and stored them in a single unit. I named this section as the “photo-geometric filter component”.

III. Algorithm

Consider a pixel located at (i,j) which needs to be denoised in image using its neighboring pixels and one of its neighboring pixels is located at(k,l). Then, the weight assigned for pixel (k,l) to de noise the pixel is given by:

$$W\,(i,j,k,l) = e^{-\left(\frac{(i-k)^2+(j-l)^2}{2\sigma_d{}^2} - \frac{\|I(i,j)-I(k,l)\|^2}{2\sigma_r{}^2}\right)}$$

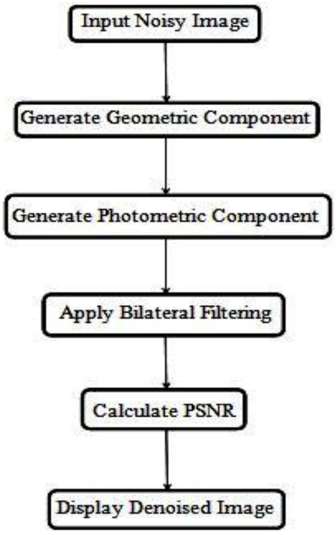
where σd and σr are smoothing parameters and I(i, j) and I(k, l) are the intensity of pixels (i,j) and (k,l) respectively. After calculating the weights, normalize them,

$$I_D\,(i,j) = \frac{\sum_{k,l} I(k,l) * w(i,j,k,l)}{\sum_{k,l} w(i,j,k,l)}$$

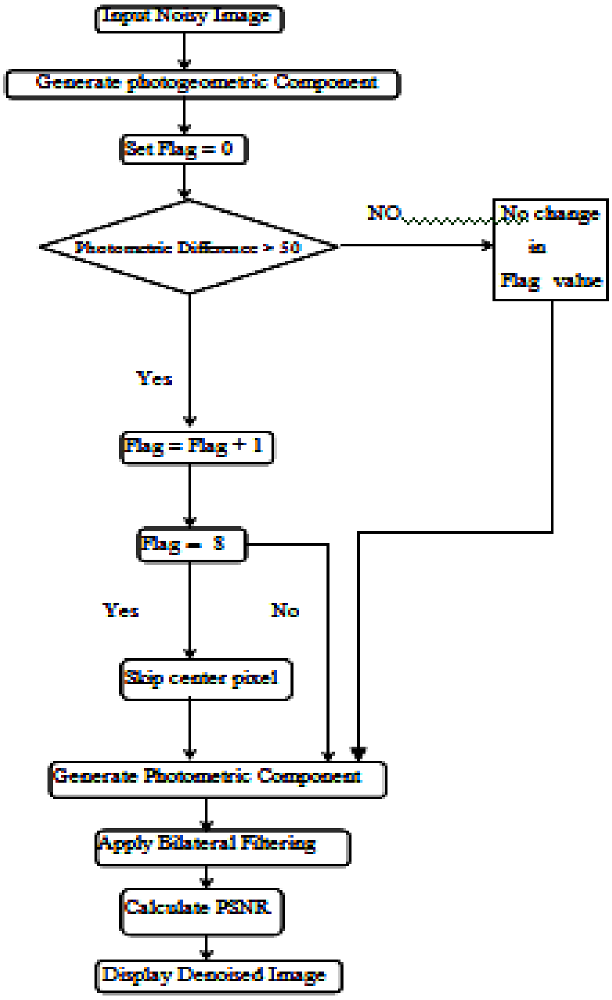
Where ID is the denoised intensity of pixel (i,j) .

Bilateral filter is modified by adding a Conditional Median Filter to improve the denoising with different noise other than Gaussian noise. If the center pixel value is more different than the surrounding value then we assume that it is not a edge and it is noise and it will be replaced by the average value of the neighboring 8 pixels. Photometric and geometric components are calculated as per the bilateral filter also the filtering operation. To calculate it in the design concept only consider two groups from the register matrix.

IV. Flow -Chart



Flowchart of Bilateral filter



Flowchart of modified bilateral filter

V. DESIGN CONCEPT

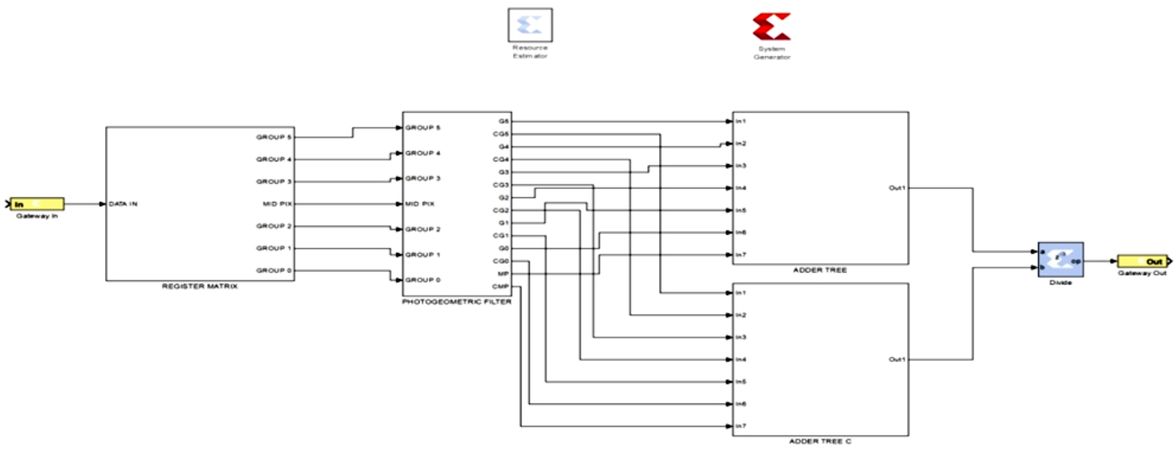


Figure shows the design of single denoise pixel using a 5x5 kernel. He image data, as well as all constants and coefficients used in the following design concept, are integer numbers. As discussed in Section VI, there is no need to implement floating point computation. With the aid of the presented design concept, the bilateral filter can be realized as a highly parallelized pipeline structure giving great importance to the effective resource utilization. For the design description, a window size of 5 x 5 is chosen.

This window size is the tradeoff between high noise reduction and low blurring effect. The disadvantage of old grouping is that we need to have two separate parts for geometric filter component. They are horizontal part and vertical part. But if we consider, the Euclidean distance as the criterion for grouping up pixels at the register matrix level, we need not to separate the geometric filter component into two and combine both photometric and geometric filter. All group element have same distance from the mid pixel so geometric components are same. This grouping technique gave me an idea for reducing the area of whole FPGA architecture.

Photo-Geometric Filter is nothing but the combination of photometric filter component and geometric filter component. The coefficients of photometric and geometric filters are pre-calculated and multiplied together and further they are scaled and stored in look-up-tables of photo-geometric filter component. The incoming grouped pixels from the register matrix are processed further at this stage. First the absolute differences of those pixels with respect to mid-pixel are found out using the comparator. These differences are fed to the look-up tables as addresses for fetching coefficients stored there. And then these differences and fetched coefficients are multiplied together finally.

The incoming grouped pixels and coefficients from the Photo-Geometric Filter are summed up separately in Adder Tree. The sum of grouped pixels is labeled as “out1”. On the other hand, the sum of coefficients is labeled as “out2”. At the final stage, the kernel result has to be normalized by out1 divided by out2 to form filtered pixel. To apply denoising to color image apply bilateral filter in three plays and combine it.

VI. CONCLUSION

I chose Euclidean distance for grouping pixels in register matrix rather than taking horizontal and vertical distances from the mid-pixel. This grouping technique gave me an idea for reducing the area of whole FPGA architecture. Then I combined the photometric filter component and geometric filter component into a single unit. In these filter components, coefficients have stored in look up tables. They are multiplied with the image pixels in subsequent steps. So we have two kinds of coefficients stored in separate sections. What I had done while reducing structure is that, I pre-calculated those coefficients separately and multiplied them together, then scaled by factor 255, and stored them in a single unit. I named this section as the photo-geometric filter component and it reduce complicity and component used.

First I implemented this idea by coding a prototype design in Matlab and successfully simulated it. For the testing purpose, I chose the variances of photometric filter component and geometric component, 60 and 1 respectively. It could denoise the images contaminated with Gaussian noise of variance 0.01.Then it code using verilog. The verilog code simulated using modelsim. Then create xilinx project and verify design it will reduce area of FPGA. I also apply modified bilateral filter with color image.

References

1. An FPGA-Based Fully Synchronized Design of a Bilateral Filter for Real-Time Image Denoising- Anna Gabiger-Rose, Student Member, IEEE, Matthias Kube, Robert Weigel, Fellow, IEEE,and Richard Rose, Student Member, IEEE, IEEE TRANSACTIONS ON INDUSTRIAL ELECTRONICS, VOL. 61, NO. 8, AUGUST 2014
2. Survey of Image Denoising Techniques – THESIS - Mukesh C. Motwani, Mukesh C. Gadiya, Rakhi C. Motwani, Frederick C. Harris, Jr.
3. DENOISING TECHNIQUES - A COMPARISON – THESIS- Sarita Dangeti, May 2003
4. C.Tomasi and P. Manduchi, "Bilateral filtering for gray and color images," in Proc. IEEE ICCV, 1998, pp. 839–846.
5. F.Durand and J. Dorsey, "Fast bilateral filtering for the display of high dynamic range images," ACM Trans. Graph. , vol. 21, no. 3, pp. 257–266, Jul. 2002.
6. T. Q. Pham and L. J. van Vliet, "Separable bilateral filtering for fast video preprocessing," in Proc. IEEE ICME, 2005, pp. 1–4. S. Paris and F. Durand, "A fast approximation of the bilateral filter using a signal processing approach," in Proc. ECCV, 2006, pp. 568–580.
7. Q.Yang, K.-H. Tan, and N. Ahuja, "Real-time O(1) bilateral filtering," in Proc. IEEE CVPR, 2009, pp. 557–564
8. B. Zhang and J. P. Allebach, "Adaptive bilateral filter for sharpness enhancement and noise removal," IEEE Trans. Image Process, vol. 17,no. 5, pp. 664–678, May 2008.
9. F. Porikli, "Constant time O(1) bilateral filtering," in Proc. IEEE CVPR, 2008, pp. 1-8
10. M.Zhang and B. K. Gunturk, "Multiresolution bilateral filter for image denoising," IEEE Trans. Image Process. , vol. 17, no. 12, pp. 2324–2333, Dec. 2008.
11. B.Yan and A.-D. Saleh, "Structure enhancing bilateral filtering of images," in Proc. IEEE PCSPA, 2010, pp. 614–617
12. R.Turney, "Two-dimensional linear filtering," in Application Note: Xilinx FPGAs, 2007, pp. 1–8.
13. C.Charoensak and F. Sattar, "FPGA design of a real-time implementation of dynamic range compression for improving television picture," in Proc. IEEE ICICS, 2007, pp.1–5.
14. T.Q.Vinh, J. H. Park, Y.-C. Kim, and S. H. Hong, "FPGA implementation of real-time edge-preserving filter for video noise reduction," in Proc. IEEE ICCEE, 2008, pp. 611–614
15. A. Rosado Muñoz, M. Bataller Mompeán, E. Soria Olivas, C. Scarante, and J. F. Guerrero Martínez, "FPGA implementation of an adaptive filter robust to impulsive noise: Two approaches," IEEE Trans. Ind. Electron. , vol. 58, no. 3, pp. 860–870, Mar. 2011.

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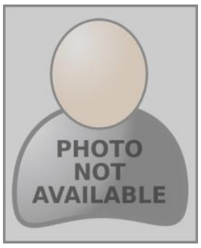

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