

Adaptive Bilateral Filter For Sharpness Enhancement And Noise Removal With Modified Boost Filtering Using FPGA

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Abstract- In this paper, we present the adaptive bilateral filter for sharpness enhancement and noise removal using high boost filtering (HBF). This filter sharpens an image by increasing the slope of the edges without producing overshoot or undershoots. It is an approach to sharpness enhancement that is fundamentally different from the unsharp mask (USM). This new approach to slope restoration also differs significantly from previous slope restoration algorithms in that the ABF does not involve detection of edges or their orientation, or extraction of edge profiles. In the adaptive bilateral filter using high boost filtering, the edge slope is enhanced by transforming the histogram via a range filter with adaptive offset and width. This filter is able to smooth the noise, while enhancing edges and textures in the image. The parameters of this filter are optimized with a training procedure. ABF with high boost filtering restored images are significantly sharper than those restored by the adaptive bilateral filter.

Keywords- Bilateral filter, de-blurring, Field Programmable Gate Array (FPGA), High boost filter (HBF), noise removal, range filter, sharpness enhancement, slope restoration, Structural Similarity (SSIM),

I. INTRODUCTION

Adaptive bilateral filtering using high boost filtering is popular in image processing due to its capability of reducing noise while preserving the structural information of an image. The detail-preserving property of the filter is mainly caused by the nonlinear filter component. It selects the pixels of similar intensity which are averaged by the linear component afterward. The amount of noise reduction via selective averaging and the amount of the blurring via low-pass filtering are both adjusted by two parameters. There are many applications in image processing such as Contrast Enhancement, Depth Reconstruction, Data Fusion, 3D Fairing where it is important to remove noise in the images before these subsequent processes. Thus various techniques for removing noise in images are described in this paper. Adaptive bilateral filtering algorithm is a non-linear and non-iterative image de-noising method in spatial domain which

utilizes the spatial information and the intensity information between a point and its neighbours to smooth the noisy images while preserving edges well. The adaptive bilateral filter is chosen for one unique reason: It reduces noise while preserving details. The adaptive bilateral filter embodies the idea of a combination of domain and range filtering. The domain filter averages the nearby pixel values and acts thereby as a low-pass filter. The range filter stands for the nonlinear component and plays an important part in edge preserving. This component allows averaging of similar pixel values only, regardless of their position in the filter window. If the value of a pixel in the filter window diverges from the value of the pixel being filtered by a certain amount, the pixel is skipped. To address the second problem of the adaptive filter, locally adaptive sharpening and smoothing algorithms have been proposed. The histogram of the edge strength is used to classify pixels into smooth regions, soft edges, and hard edges, which are subsequently processed with different sharpening strengths.

II. LITERATURE SURVEY

Many researchers have worked on image de-noising techniques. The adaptive bilateral filter (ABF) for sharpness enhancement and noise removal is presented [1]. A noise reduction method and an adaptive contrast enhancement for local tone mapping (TM) is presented [2].

A parallel version of the bilateral filter using a lazy sliding window, suitable for SIMD type architectures is presented [3]. An efficient and scalable design for histogram-based bilateral filtering (BF) and joint BF (JBF) by memory reduction methods and architecture design techniques to solve the problems of high memory cost, high computational complexity, high bandwidth, and large range table is presented [4]. Mithun Das Gupta, Jing Xiao (2010) proposed a new filter called Bi-affinity filter for color images. This filter is similar in structure to the bilateral filter. which does not require the explicit conversion of the RGB values to perception based spaces such as CIELAB. The bi-affinity filter measures the affinity of a pixel to a small neighbourhood around it and weighs the filter term accordingly. We show that this method

can perform at par with standard bilateral filters for color images. The small edges of the image are usually enhanced leading to a very easy image enhancement filter [5]. Xing-Fang Huang; Jiang-She Zhang (2009) proposed a novel local adaptive noise reduction operator based on a location shifting procedure. Performance of the method is illustrated by simulation and real images, which show an encouraging improvement compared with other methods.[6].

Adaptive Bilateral filter (ABF) proposed by Zhang and Allebach in the year 2008 which not only smoothes the image but also sharpens the image by increasing the slope of the edges. The main disadvantage of this filter is that it does not sharp the edge at greater level. It just removes the noise present in an image and smoothes the image. [7]

III. PROPOSED METHODOLOGY

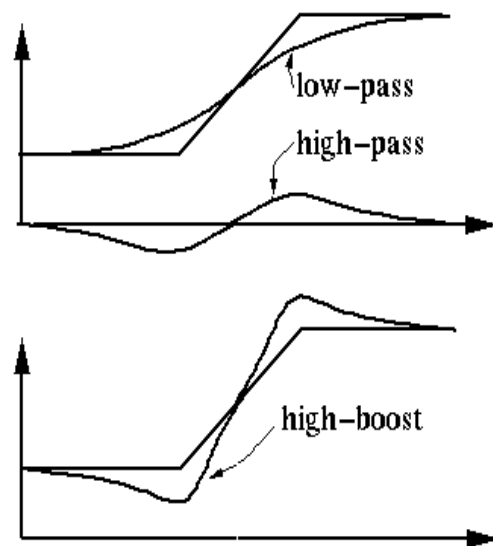
As discussed above, Adaptive Bilateral filter is a smoothening filter and it doesn't sharpen the edges of image at greater level. To overcome this limitation, an Adaptive Bilateral filter using high boost filtering is proposed which not only smoothes the image but also sharpens the image by greater extent by increasing the slope of the edges.

ABF with high boost filtering remains same from its previous version in two ways. Firstly an offset ϕ is introduced to the range filter so as to shift the range filter on the histogram and this causes sharpening of edges. The other modification done is making the width of the range filter, σ_r adaptive. It helps in identifying which pixel values are similar and needs to be averaged. But it mainly differs with previous algorithm that is, it is often desirable to emphasize high frequency components representing the image details (by means such as sharpening) without eliminating low frequency components representing the basic form of the signal. In this case, the high-boost filter can be used to enhance high frequency component while still keeping the low frequency components:

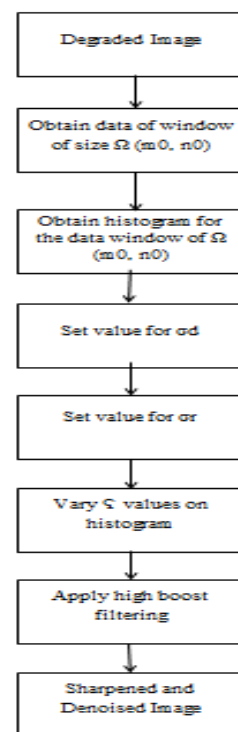
$$\begin{aligned} \text{HBF image} &= k(\text{original image}) - \text{LPF image} \\ &= (k-1) \text{ original image} + \text{original image} - \text{LPF} \\ &= (k-1) \text{ original image} + \text{HPF image} \end{aligned}$$

where k is any positive scaling factor.

For k=1, HBF image = HPF image.



FLOWCHART



ALGORITHM

- STEP 1: Start.
- STEP 2: Read input image.
- STEP 3: Verify image exists and is valid.
- STEP 4: Differentiate between grey scale and colour image.
- STEP 5: Obtain the data of window size $\Omega (m_0, n_0)$ on the image
- STEP 6: Obtain histogram for the data window size $\Omega (m_0, n_0)$ on the image.

- STEP 7: Set value for σ_d
- STEP 8: Set value for σ_r
- STEP 9: Vary ζ values on histogram
- STEP 10: Apply high boost filtering
- STEP 11: Sharpened and De-noised image
- STEP 12: End

ADVANTAGES

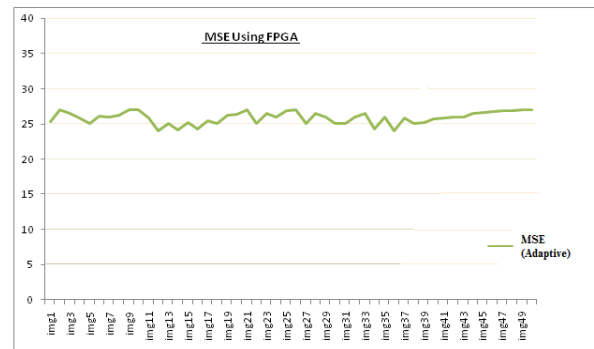
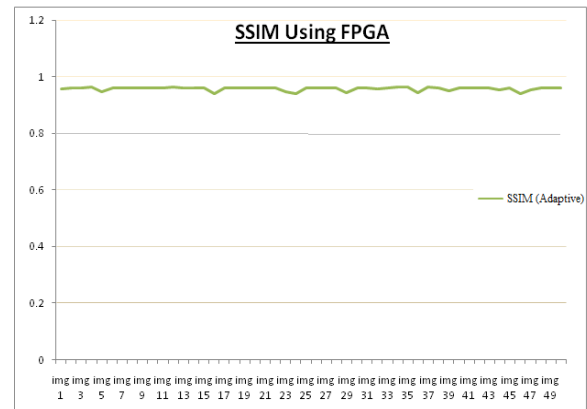
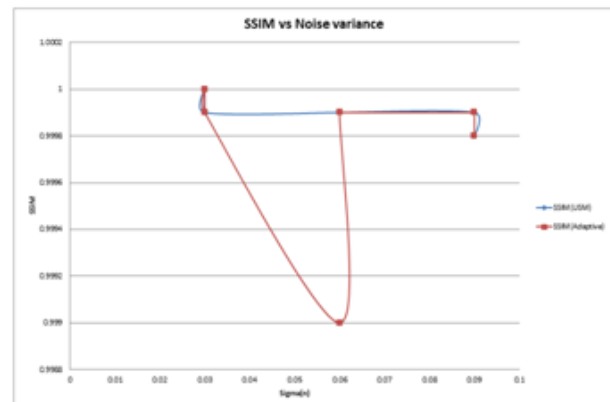
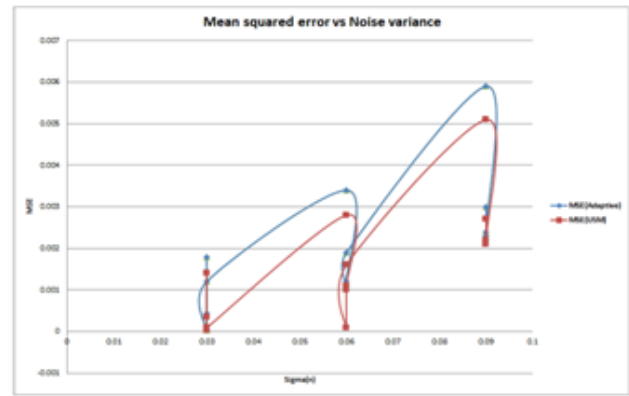
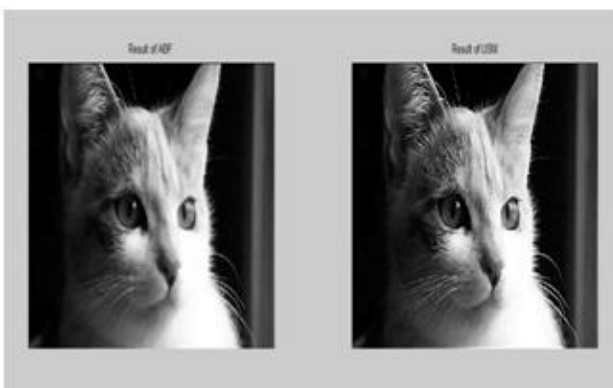
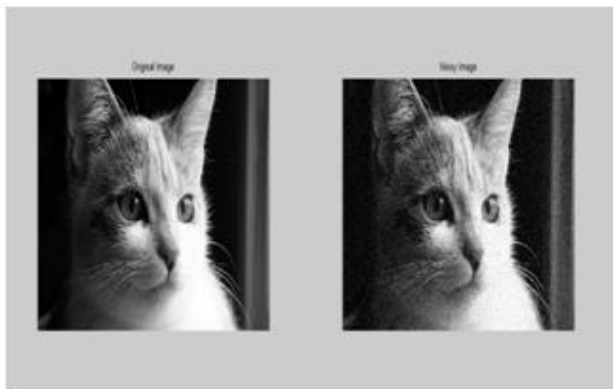
It sharpens images by increasing the slope of the edges over the conventional bilateral filter.

By combining offset and range of width filter, the technique becomes much more powerful and versatile. As a result overall quality of de-noised is improved.

High frequency components are emphasized without eliminating low frequency component hence renders sharpen image.

IV. RESULTS AND DISCUSSION

Fig1: Original Image, **Fig2:** Noisy Image, **Fig3:** Result of Adaptive bilateral filter, **Fig4:** Result of Adaptive bilateral filter with high boost filtering.



The study shows that the adaptive bilateral filter with high boost filtering has greater efficiency. The peak SNR is higher in case of adaptive bilateral filter than the conventional

filtering. And by observing the graph of SSIM (Structural Similarity Index) we get to know that the quality of image after ABF using FPGA is better as compared to normal adaptive bilateral filter.

V. CONCLUSION

In this project, we presented an adaptive bilateral filter using high boost filtering. The filter out performs the adaptive bilateral filter in noise removal. At the same time, it renders much sharper images than the conventional bilateral filter does. As compared other filters/algorithms the high frequency components of image are emphasized without eliminating low frequency component. This proposed filter is more efficient to implement, and provides a more reliable and more robust solution to slope restoration. As a result, the overall quality of the restored image is significantly improved.

REFERENCES

- [1] Anna Gabiger-Rose, Student Member, IEEE, Matthias Kube, Robert Weigel, Fellow, IEEE, and Richard Rose, Student Member, IEEE —AnFPGA-Based Fully Synchronized Design of a Bilateral Filter for Real-Time Image Denoising, IEEE Trans on Industrial Electronics, vol. 61, no. 8, August 2014.
- [2] Y.-C. Tseng, P.-H.Hsu, and T.-S. Chang, —A 124 Mpixels/sec VLSI design for histogram-based joint bilateral filtering, in IEEE Trans. Image Process., Nov. 2011, vol. 20, no. 11, pp. 3231–3241.
- [3] J. Won Lee, R.-H. Park, and S. Chang, —Noise reduction and adaptive contrast enhancement for local tone mapping, IEEE Trans. Consum.Electron., vol. 58, no. 2, pp. 578–586, May 2012.
- [4] M. M. Bronstein, —Lazy sliding window implementation of the bilateral filter on parallel architectures, IEEE Trans. Image Process., vol. 20, no. 6, pp. 1751–1756, Jun. 2011.
- [5] Mithun, Das Gupta, & Jing, Xiao. (2010). Bi-affinity Filter: A Bilateral Type Filter for Color Images. In Workshop on Color and Reflectance in Computer Vision (CRICV) in conjunction with ECCV
- [6] Xing-fang, Huang, & Jiang-she Zhang. (2009). Edge-Preserving Filtering for Grey and Color Image. In Proc. of the IEEE/Computer Science and Information Engineering, 5, 139-143.
- [7] 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.
- [8] Buyue Zhang, Member, IEEE, and Jan P. Allebach, Fellow, IEEE-Adaptive Bilateral Filter for Sharpness Enhancement and Noise Removal. IEEE Transactions on image processing, vol. 17, no. 5, may 2008.
- [9] Rafael, C. Gonzalez, & Richard, E. Woods. Digital Image Processing (3rd Edition).Pearson Publication.