

FPGA IMPLEMENTATION OF BILATERAL FILTER AND OPTIMAL PARAMETER ESTIMATION FOR IMAGE DENOISING

A. Manoj Prabakaran

M.E Student, Raja College of Engineering and Technology, Madurai, TamilNadu, (India)

ABSTRACT

An image is often corrupted by noise in its acquisition or transmission. The goal of denoising is to remove the noise while retaining as much as possible the important signal features. The bilateral filter is a local non-linear filter, that's response depends on both gray level similarities and geometric closeness of the neighboring pixels without smoothing edges. The filter's neighbor pixel size and width (σ) determines efficiency of the filter. Hence, an important issue with the application of the bilateral filter is the selection of the filter parameters, which affect the results significantly. We propose particle neighbor scale and filter's widths for spatial and Intensity of the bilateral filter extracted from scaled image.

Keywords: *Image Noises , Bilateral Filter, Image Restoration.*

I. INTRODUCTION

An image is a visual representation of an object, a person, or a scene produced by an optical device such as a mirror, a lens, or a camera. This representation is two dimensional (2D), although it corresponds to one of the infinitely many projections of a real-world, three-dimensional (3D) object or scene. A digital image is a representation of a two-dimensional image using a finite number of points, usually referred to as picture elements, pels, or pixels. Each pixel is represented by one or more numerical values: for monochrome (grayscale) images, a single value representing the intensity of the pixel (usually in a [0, 255] range) is enough; for color images, three values (e.g., representing the amount of red (R), green (G), and blue (B)) are usually required.

Binary images are the simplest type of images and can take only two discrete values, black and white. Black is represented with the value '0' while white with '1'. Note that a binary image is generally created from a gray-scale image. A binary image finds applications in computer vision areas where the general shape or outline information of the image is needed. They are also referred to as 1 bit/pixel images. Gray-scale images are known as monochrome or one-color images. The images used for experimentation purposes in this thesis are all gray-scale images. They contain no colour information. They represent the brightness of the image. This image contains 8 bits/pixel data, which means it can have up to 256 (0-255) different brightness levels.

A '0' represents black and '255' denotes white. In between values from 1 to 254 represent the different gray levels. As they contain the intensity information, they are also referred to as intensity images. Color images are considered as three band monochrome images, where each band is of a different color. Each band provides the

brightness information of the corresponding spectral band. Typical color images are red, green and blue images and are also referred to as RGB images. This is a 24 bits/pixel image.

II. IMAGE NOISES

A very large portion of digital image processing is devoted to image restoration. This includes research in algorithm development and routine goal oriented image processing. Image restoration is the removal or reduction of degradations that are incurred while the image is being obtained. Degradation comes from blurring as well as noise due to electronic and photometric sources. Blurring is a form of bandwidth reduction of the image caused by the imperfect image formation process such as relative motion between the camera and the original scene or by an optical system that is out of focus. When aerial photographs are produced for remote sensing purposes, blurs are introduced by atmospheric turbulence, aberrations in the optical system and relative motion between camera and ground. In addition to these blurring effects, the recorded image is corrupted by noises too. A noise is introduced in the transmission medium due to a noisy channel, errors during the measurement process and during quantization of the data for digital storage. Each element in the imaging chain such as lenses, film, digitizer, etc. contribute to the degradation.

Image denoising is often used in the field of photography or publishing where an image was somehow degraded but needs to be improved before it can be printed. For this type of application we need to know something about the degradation process in order to develop a model for it. When we have a model for the degradation process, the inverse process can be applied to the image to restore it back to the original form. This type of image restoration is often used in space exploration to help eliminate artifacts generated by mechanical jitter in a spacecraft or to compensate for distortion in the optical system of a telescope. Image denoising finds applications in fields such as astronomy where the resolution limitations are severe, in medical imaging where the physical requirements for high quality imaging are needed for analyzing images of unique events, and in forensic science where potentially useful photographic evidence is sometimes of extremely bad quality.

III. RELATED WORK

T. Q. Vinh, J. H. Park, Y.-C.Kim, and S. H. Hong have proposed “FPGA Design And Implementation Of A Wavelet-Domain Video Denoising System” Multiresolution video denoising is becoming an increasingly popular research topic over recent years. Although several wavelet based algorithms reportedly outperform classical single-resolution approaches, their concepts are often considered as prohibitive for real-time processing. Little research has been done so far towards hardware customization of wavelet domain video denoising. A number of recent works have addressed the implementation of critically sampled orthogonal wavelet transforms and the related image compression schemes in Field Programmable Gate Arrays (FPGA). However, the existing literature on FPGA implementations of over complete (non-decimated) wavelet transforms and on manipulations of the wavelet coefficients that are more complex than thresholding is very limited. In this paper we develop FPGA implementation of an advanced wavelet domain noise interring algorithm, which uses a non-decimated wavelet transform and spatially adaptive Bayesian wavelet shrinkage. The standard composite television video stream is digitalized and used as source for real-time video sequences. The results demonstrate the effectiveness of the developed scheme for real time video processing.

F.Hannighave proposed “A Deeply Pipelined and Parallel Architecture For Denoising Medical Images” the filter consists of 16 parallel working modules, where the most computationally intensive module achieves software pipelining of a factor of 85, that is, computations of 85 iterations overlap each other. By applying a state-of-the-art high-level synthesis tool, we show that this approach can be used for real world applications. In addition, we show that our high level synthesis tool is capable of significantly reducing the well-known productivity gap of embedded system design by almost two orders of magnitude. Finally, we can conclude that the FPGA implementation of the multiresolution image processing algorithm is far ahead of a comparable implementation for graphics cards in terms of power efficiency. Multiresolution video denoising is becoming an increasingly popular research topic over recent years. Although several wavelet based algorithms reportedly outperform classical single-resolution approaches, their concepts are often considered as prohibitive for real-time processing. However, the existing literature on FPGA implementations of overcomplete (non-decimated) wavelet transforms and on manipulations of the wavelet coefficients that are more complex than thresholding is very limited. In this paper we develop FPGA implementation of an advanced wavelet domain noise itering algorithm, which uses a non-decimated wavelet transform and spatially adaptive Bayesian wavelet shrinkage. The standard composite television video stream is digitalized and used as source for real-time video sequences. The results demonstrate the effectiveness of the developed scheme for real time video processing.

Gabiger-Rose, M. Kube, P. Schmitt, R. Weigel, and R. Rose have developed “Medical Image Denoising On Field Programmable Gate Array Using Finite Random Transform” This study presents the design and implementation of efficient architectures for finite Radon transform (FRAT) on a field programmable gate array (FPGA). FPGA-based architectures with two design strategies have been proposed: direct implementation of pseudo-code with a sequential or pipelined description, and a block random access memory-based approach. Various medical images modalities have been deployed for both software evaluation and hardware implementation. Xilinx DSP tool has been used to improve the implementation time and reduce the design cycle and the Xilinx software has been used for generating a hardware description language from a high-level MATLAB description. Objective evaluation of image denoising using FRAT is carried out and demonstrates promising results. Moreover, the impact of different block sizes on image reconstruction has been analysed. Performance analysis in terms of area, maximum frequency and throughput is presented and reveals significant achievements.

B. K. Shreyamsha Kumar have proposed “Image Denoising By Thresholding In The Wavelet Domain And Implementation In FPGA Using VHDL” Here Wavelet transform has the advantage of visualizing the parameter both in Time and Frequency Domain this technique has been effective in noise removal with minimum side effects on important features such as image details and edges. It gives VLSI architecture implementation in FPGA for image processing. The image decomposed into L levels and the detail and approximation coefficients are found and the denoising using Hard and Soft thresholding is applied and the denoised coefficients are reconstructed to get the denoised image. Efficient hardware implementation based on FPGA technology is proposed. The image processing toolbox [Im01] in Matlab provides the medfilt2() [Appendix] function to do median filtering on an image. The input image and the size of the window are the parameters the function takes.

IV. PROPOSED WORK

Denosing has long been a focus of research and yet there always remains room for improvement, especially in image denosing. The simple spatial filtering of a corrupted image can be successful when high frequency noise is to be removed from the corrupted image. The main difficulty associated with this is, the computational complexity involved in performing the convolution. The goal of image denosing is to remove the noise while retaining the important image features like edges, details as much as possible. Linear filters, which consist of convolving the image with a constant matrix to obtain a linear combination of neighborhood values, have been widely used for noise elimination in the presence of additive noise. Bilateral Filter proposed in considers both spatial and intensity information between a point and its neighboring points, unlike the conventional linear filtering where only spatial information is considered. This preserves the edges/sharp boundaries very well while noise is averaged out as it average pixels belonging to the same region as the reference pixel. The denosing performance of bilateral depends on gaussian filter coefficient. The Gaussian filter designed with tow parameters neighboring window size and sigma value of filters. The adaptive changing the parameters give better denosing results as well as fast of completion of denosing process. The proposed bilateral filter perfume better denosing process over existing method of bilateral filter comparison done by quality of denoised image in terms of psnr (peak signal to noise ratio) and mse (mean square error) value. The both filter sigma value estimated adaptively from local region of image The sigma value of the bilateral filter is estimated from Z-score value of local neighborhood pixels.

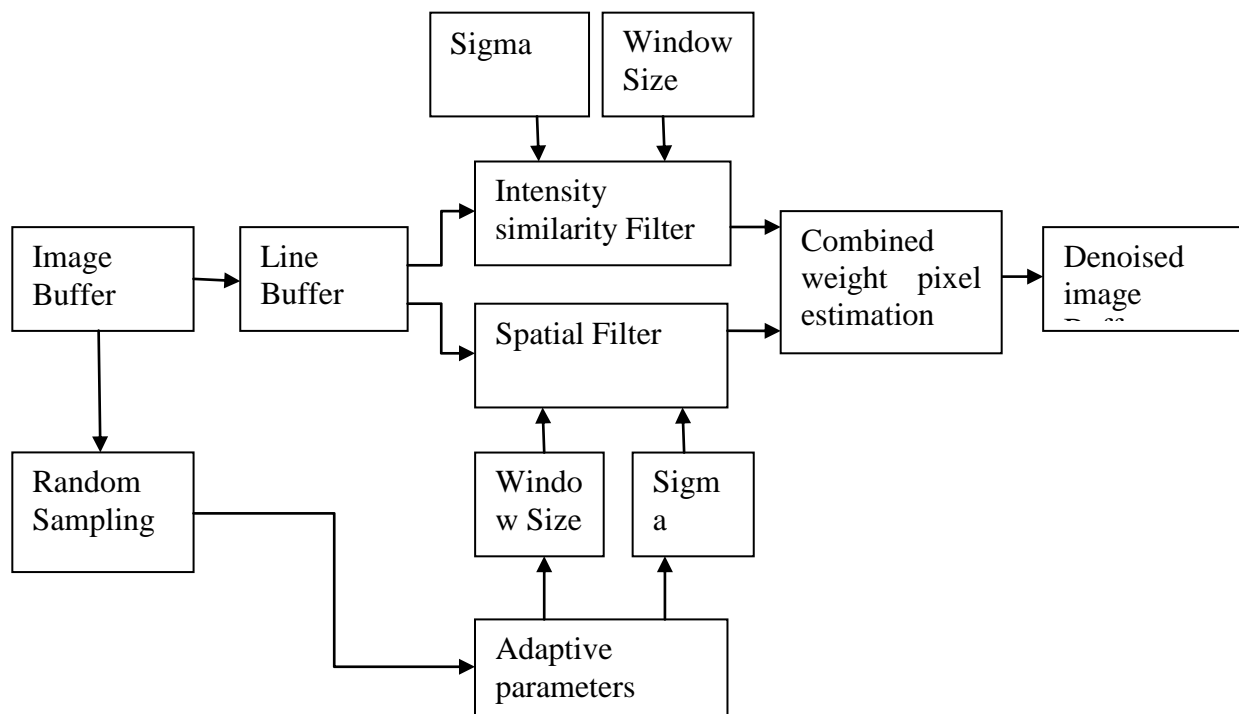



Fig 4.1 Block Diagram

V. SIMULATION RESULT

To open the Xilinx ISE 10.1, click on the Xilinx icon  on the desk top or go to the **Start -> Programs -> Xilinx ISE Design Suit 10.1 -> ISE -> Project Navigator**

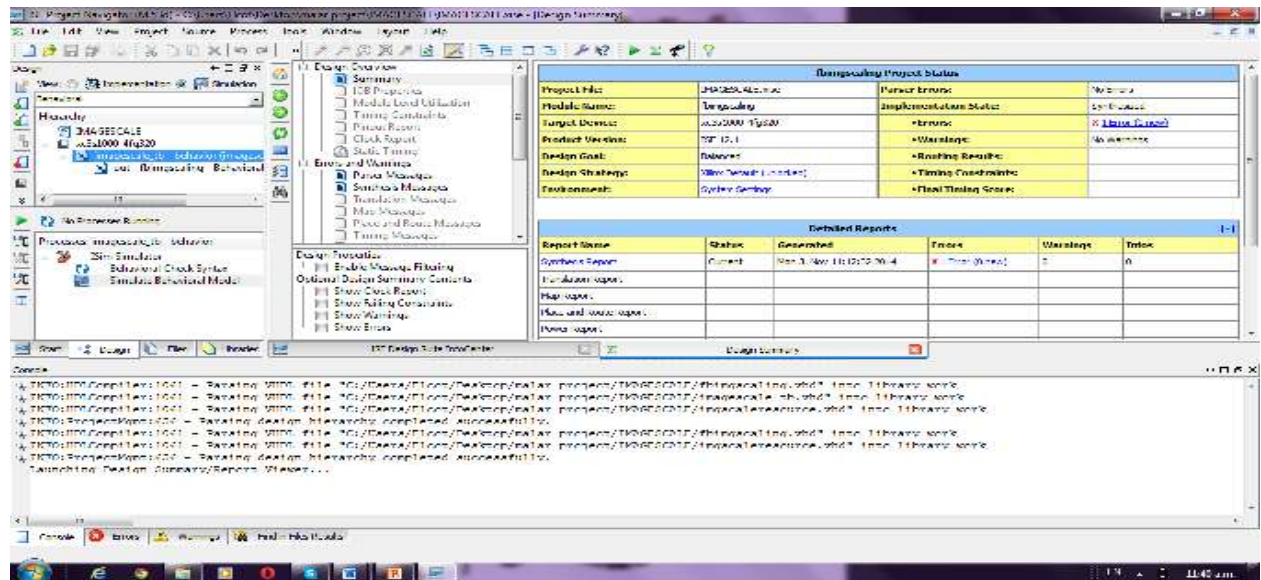


Fig 5.1 Starting Window

To create the process and write the code for producing the output

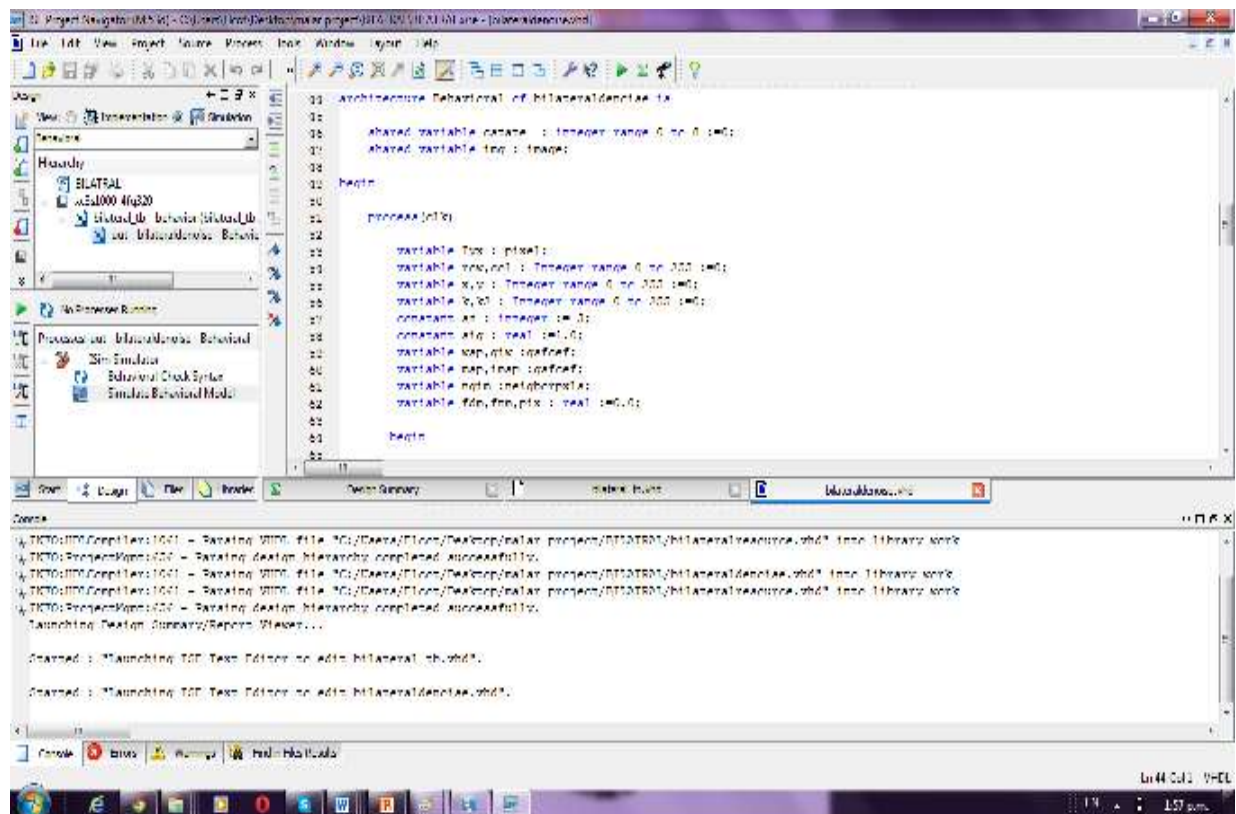


Fig 5.2 Processing Window

Output waveform

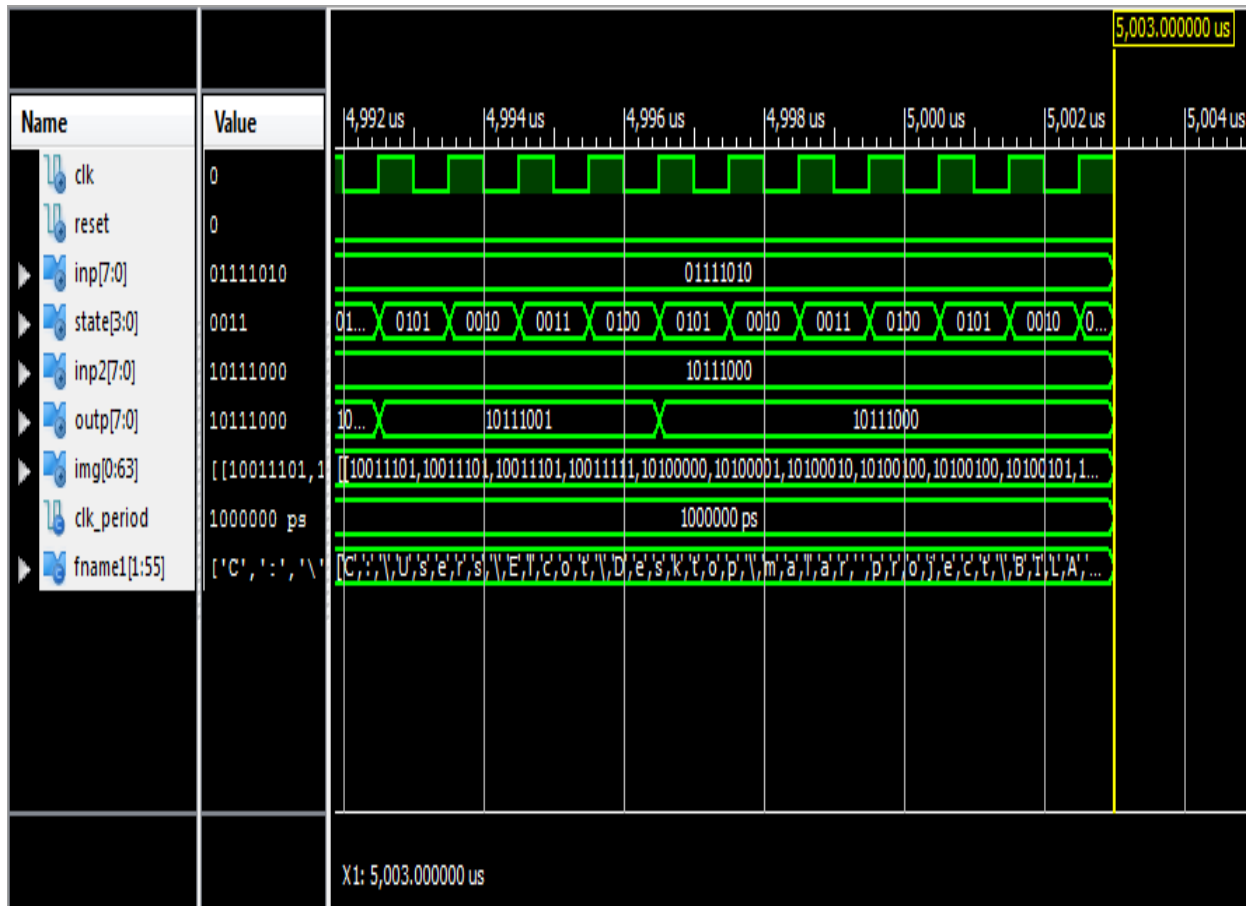


Fig 5.3 Output Waveform for Denoised Image

VI. CONCLUSION

Bilateral filter for image adaptive denoising process in FPGA using vhdl hardware language. The image denoising performance of bilateral improved by adaptively determining filter parameters (size and sigma) instead of fixed filter’s size and sigma. The adaptive changing the parameters give better denoising results as well as fast of completion of denoising process than fixed filter model. The denoised Image quality was assessed with PSNR (peak signal to noise ratio) and MSE (mean square value) value.

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