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FPGA Based Implementation of Video Denoising Using Warped Filter

V.Thenmozhi, G.Themozhi.

Abstract— Noise in video signal plays a major problem in most of the communication systems. Video denoising is the process of removing noise from the video signal. In order to increase compression effectiveness and improve subjective quality of video sequences video denoising process using Warped Filter is done. Warped Filter is an all pass filter; it is widely used for various video and audio processing applications. This project proposes the design, simulation and implementation of a real time video denoising on FPGA. Contourlet transform is proposed as an alternative over Wavelet transform. The Gaussian noise presents in the input signal is removed effectively. Initially a software model is constructed using MATLAB, and then with the same data's, the hardware implementation using FPGA is done for the proposed Video denoising architecture.

Index Terms— warped filter, Contourlet transform, Gaussian noise, FPGA.

1 Introduction

Video denoising is a major problem in most electronic communication systems. In the video transmission and television broadcasting systems, video denoising can increase compression effectiveness, and thus save transmission bandwidth. In the surveillance and teleconferencing applications, video denoising can reduce noise due to poor lighting or low-bit-rate compression, and consequently improve subjective quality of video sequences. Video noise is usually caused by electronic instability, thermal fluctuations, analog to digital conversion process, poor light condition, and etc. The noise contribution is often modelled as an independent additive white Gaussian process. Traditional low pass filter can filter out all the high frequency and suppress noise; however, it destroys details of image frames. Some advanced denoising methods have been proposed using multi resolution representative of images. Contourlet is a new emerging transformation method to decompose an image into subbands which are characterized as multi resolution, localization, critical sampling, critical sampling, directionality, and anisotropy.

Duncan and Minh.N.Do (2004) modelled the contourlet transform as a new extension to the wavelet transform in two dimensions using non separable and directional filter banks. He model contourlet coefficients using a hidden Markov tree (HMT) model that can capture all of their inter-scale, inter-orientation, and intra-subband dependencies. In denoising, contourlet HMT outperforms wavelet HMT and other classical methods in terms of visual quality. The author concluded the results that are highly promising. In denoising,

Contourlet HMT can preserve edges and lines better than wavelet HMT and other classical methods, and also produces superior visual quality in the denoised images.

Martin Veterli (2005) Proposed the limitations of commonly used separable extensions of one-dimensional transforms, such as the Fourier and wavelet transforms, in capturing the geometry of image edges are well known. The author concluded that a discrete transform that provides a sparse expansion for typical images having smooth contours. Vladimir (2006) introduced that the proposed novel video denoising method based on non decimated wavelet band filtering. Florian (2010) proposed an efficient orthonormal wavelet-domain video denoising algorithm based on an appropriate integration of motion compensation into an adapted version of recently devised Stein's unbiased risk estimator-linear expansion of thresholds (SURE-LET) approach.

The paper is organised as follows. Section II is about Video denoising using Contourlet transform. Section III describes about the Hardware Architecture, Warped filter and the design procedure of Contourlet transform. In Section IV is about adaptive Thresholding, and with section V Simulated results is presented. Finally conclusions are given.

2 Video denoise using contourlet transform

Denoising the image from the original input image involves the use of Contourlet transform, prior to the Wavelet transform. Contourlet transform outperforms the Wavelet transform in terms of high degree of anisotropy, directionality and Multiresolution.

2.1 Contourlet Transform

Contourlet transform is an efficient directional multi resolution image representation. It is developed as an improvement over wavelets as high degree of directionality and anisotropy.

The contourlet transform is implemented by first applying a wavelet-like multi scale transform such as Laplacian pyramid

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(LP), and then followed by a local directional filter bank (DFB). Fig 1 shows the implementation of contourlet filter bank, where (2,2) is the downsampling matrix with a diagonal form.

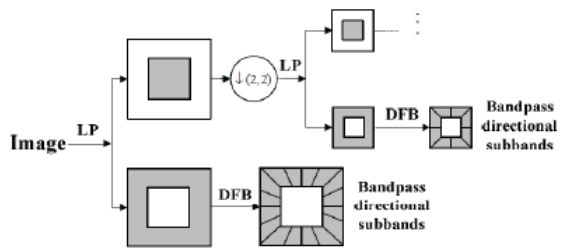

Fig. 1. The Contourlet Filter Bank

3 Hardware Architecture

The Fig 2 shows about the Hardware design of video denoising

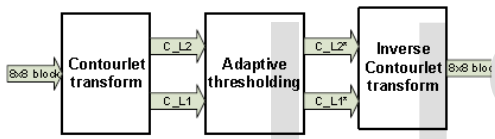

Fig. 2. Top Block Hardware Design of Video denoising

As shown in Fig 2 is the design processes block by block with the size 8×8 pixels. The full pipeline structure is applied for the design of video denoising. All blocks of the design are synchronized by a unique clock signal and clock enable signal.

In summary, the proposed video denoising method using adaptive thresholding in contourlet transform is described as follows:

STEP 1: Perform contourlet transform to noisy video frames
STEP 2: Compute threshold (T) for the contourlet coefficients
STEP 3: Apply threshold (T) for the contourlet coefficients of noisy video frames
STEP 4: Reconstruct denoised video frame by using inverse contourlet transform.

Warped Filter

Video denoising process involves the architecture using warped filter. An efficient implementation of reconfigurable warped digital filter with variable low-pass, high-pass, bandpass, and bandstop responses is presented. The warped filters, obtained by replacing each unit delay of a digital filter with an all-pass filter, are widely used for various audio processing applications. The proposed architecture provides variable low-pass or high-pass responses with fine control over cut-off frequency.

Design of Contourlet Transform

The design of the contourlet transform block is divided into 4 sub blocks: Laplacian Pyramid Level 1 (LP_L1), Laplacian Pyramid Level 2 (LP_L2), Directional Filter Bank Level 1 (DFB_L1), and Directional Filter Bank Level 2 (DFB_L2). The block diagram of CT block as shown in Fig 3.

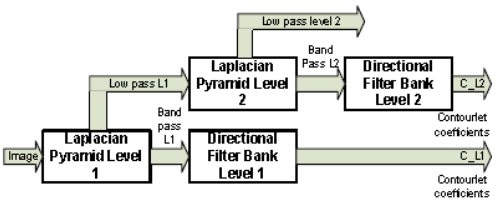

Fig. 3. Block diagram of contourlet transform

The LP_L1 and the DFB_L1 are used to generate representatives of the first resolution of noisy video frames. The LP_L2 receives low pass level 1 data, and then produces band pass level 2 data for the DFB_L2.

4 Adaptive Thresholding

The thresholding approach is sensitive to noise components. In this approach, noisy transform coefficients (high frequency components) are attenuated, whose amplitudes are smaller than a certain statistical threshold value, to zero while retaining the smoother transform coefficients to reconstruct the ideal image without much loss its details.

The full binary tree decomposition of the DFB in the contourlet transform can be generalized to arbitrary tree structures, similar to the wavelet packets generalization of the wavelet transform. The result is a family of directional multi-resolution expansions, which called contourlet packets. Fig 4 and 5 shows examples of possible frequency decompositions by the contourlet transform and contourlet packets. In particular, contourlet packets allow finer angular resolution decomposition at any scale or direction, at the cost of spatial resolution.

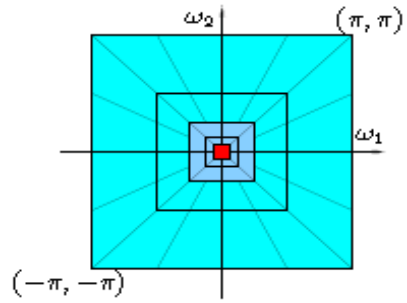

Fig. 4. Frequency decomposition of contourlet transform

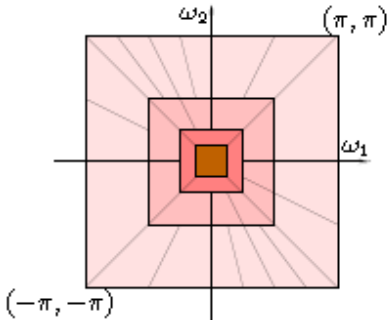

Fig. 5. Contourlet packets

The input image is shown in the Fig 6 respectively

Fig. 6. Input Image

The Coarse image is shown in the Fig 7 respectively

Fig. 7. Coarse Image

The Detailed image is shown in the Fig 8 respectively

Fig. 8. Detailed Image

Input image is applied as an input to the Transform, outcomes the results as the coarse image, it represents the Low pass filter in the analysis of the row process. Detailed image represents the High pass filter in the analysis of the Column process.The signal to noise ratio is shown in the Fig 9 respectively

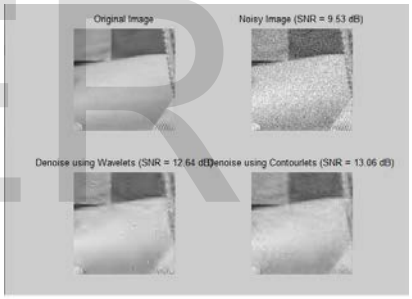

Fig. 9. Signal to noise ratio

Comparison of signal to noise ratio (SNR) between the Wavelet Transform and Contourlet Transform of denoised image. The ratio of the average squared value of the source and the (MSE) mean square error as SNR. It is expressed in decibels (dB).

Fig. 10. Denoised image

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6 Conclusion

The Denoised image is obtained from the input noisy image, by the proposed Adaptive thresholding algorithm which is constructed in MATLAB software. In prior to the Hardware Implementation, A software model for the denoising algorithm is built in Matlab. In this thesis performing comparison between Matlab model and architecture model to verify the functionality of the proposed hardware design. The Algorithm is capable of removing the noise from the input image, in particular of the additive White Gaussian Noise. The SNR (signal to noise ratio) is obtained for Wavelet Coefficients are 12.64 db and SNR (signal to noise ratio) obtained for Contourlet Transform is 13.64 db. From this result it is concluded that the Contourlet Transform outperforms well when compared with Wavelet Transform.

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