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VLSI IMPLEMENTATION OF MODIFIED GUIDED FILTER FOR REAL TIME VIDEO

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ABSTRACT

Filtering techniques are used in image and video processing applications for various technologies. Field Programmable Gate Array (FPGA) technology has become a viable target for the implementation of real time algorithms and it is suitable for real time video image processing applications. Explicit type of image filter called the guided filter is proposed to remove the noise in video by smoothing and sharpening of image frames and it is also used to preserve the edges. Weighted least square filter is used to remove the halo effect. Here, the systolic array architecture is proposed for modified guided filter. Systolic array architecture is an efficient data to improve the pipeline and parallel processing. The guided filter is derived from the local linear model which computes the filtered output by considering the content of the guided frame as the input frame. It can also transfer the structure of filtering image to the filtering output enabling the filtering application like dehazing and guided feathering. Application such as Computer vision and computer graphics includes edge-aware smoothing, HDR compression, image matting. FPGA can be used to implement any logical function that an ASIC could perform. Efficient modified guided filter architecture is implemented on cyclone II FPGA device which offers less cost, speed and supports the NTSC video.

Keywords: edge preserving filtering, linear time filtering, weighted least square filter.

1. INTRODUCTION

Real time image and video processing are used in a wide variety of application from video surveillances and traffic management to medical image application. Many new and exciting innovation such as HDTV and digital cinema involved image and video processing. Standard NTSC video are digitalized at the frame rate of 720x 480.NTSC color encoding used with the system M television signal consists of 29.97 interlaced frames of video per seconds. Each frame is composed of two field consisting 262.5 scan lines for a total scan line of 525 and 483 scan lines are make a visible data. Vertical blocking interval allow the vertical synchronization and retrace. NTSC field refresh in the black and white color originally extract the matched nominal color of 60Hz frequency replacement the power.

NTSC use a luminance- chrominance encoding system. The three color picture signals are divided into RGB (Red, green, blue).Chrominance signal are carry only the color information.

Transmitted broadcast signal of NTSC is the amplitude modulate radio- frequency. Videos and images are acquired by a camera or other imaging system. The images and videos are may be corrupted by the random noise variation in intensity. Smoothing techniques are used to remove the noise. Common types of noise are salt and pepper, impulse noise, gaussian noise etc. Noises are corrupted in the improper focusing. Haze effect, relative object camera motion, fog. Guided image filtering, is the task of matching the images taken from a stereo camera and extract depth of the objects in a scene [3] is commonly employed in the embedded vision applications such as the intelligence surveillance, autonomous vehicles and mobile robots . Such applications need to satisfy real -time processing speed, high matching accuracy and low-power consumption constraints. The modified guided filter algorithm and the implementation platform are both factors that play a significant role in satisfying the requirements of an embedded stereo matching system. Accurate results are produced by the global stereo matching algorithm but rely on the high-end hardware resources of multi-core CPUs and/or GPU platforms to achieve real-time processing [2].

Local algorithms can be greatly benefited by using the parallel structures implemented on either FPGAs or ASICs, providing by the necessary computational power and energy efficiency for embedded vision applications. However, the majority of them have implemented local algorithms that rely on standard block-based aggregation with a fixed support window [2]. While these algorithms can achieve very high frame rates when implemented in hardware, they lead to low matching accuracy. However, existing implementations have made several modifications and simplifications to adapt the algorithms for real-time processing, resulting in noticeable quality reduction compared to the original software algorithms. To apply the modified guided filter for removal noise in image and video. We propose a simple and non-iterative algorithm modified guided filter algorithm for real time NTSC video. Modified guided filter is used to preserve the edges at the same time of smoothing process. Systolic array architecture are used for increasing the speed.

There are two main concepts in this paper. First, its presents a new and efficient hardware design of the modified guided filter .They reduces the overall hardware complexity of cost aggregation, which in turn allows real-time stereo matching of high definition images (HD), as well as improvements of the speed and reduce power and area.

In the following: Sections II & III provide background and related work, while Section IV presents the proposed hardware implementation. Section V shows results and comparison with related work. Finally, VI section concludes this paper.

2. BACKGROUND ON FILTERING METHODS

a. Filtering process

Most of the images are disturbed by the some extent noise that is unexplained variation in the pixel intensity level. Image filter may be used to emphasize the data in images. Filters are used to change the pixel value by taking into the account of neighboring value pixel. [14] Display the weight of the 5x5 moving average filter. Calculated the pixel value and each pixel value has been replaced by the average of the pixel value in a 5x5 centered on the square pixel or window. Filters are used to reduce the noise in image .Moving average filter is subtracted from the original image based on the pixel by pixel calculation. The largest negative values are displayed in the black color and the largest positive values are shown in the white color. There are two types of filter 1) Linear filter and 2) Non-linear filter

There are two domains in the linear filter a) Spatial domain b) Frequency domain.

b) Linear filter in spatial domain

Consider the image intensity f(x, y) to be specified for the continuously varying the row index y and column index x, and to be differentiable. In image have been displayed with zero pixel as mid-grey and positive value are shown in the lighter grey negative values are shown in the darker grey.

c) Linear filter in frequency domain

Representing an image as an image as an n x n array of the pixel value and represent the sum of many sine wave of different frequency amplitude and direction. Calculate the weight of the pixel in the first derivatives and second derivatives.

d) Non linear edge detection filter

Non -linear filter can smooth the image without blurring edges and can detect the edge in the image. Non linear filter are simultaneously reduce noise and preserve edges in the image.

1) Roberts filter

The sum of the absolute difference are diagonally opposite pixel value [5].

$$g_{ij} = | f_{ij} - f_{i+1,}f_{j+1}| + |f_{i+1,j} - f_{i,j+1}|$$

2) Kirsch filter

Template matching filter the filter output is maximum response for a set of linear filter which are sensitive to edge at different.

3. RELATED WORK

In recent years, a fair amount of work has been carried out on real-time hardware implementations of local stereo matching algorithms (e.g. [13]); a thorough review is presented in [3]. The bilateral filter is a non-linear filter that does spatial averaging without smoothing edges. Bilateral filter is an effective image denoising technique.

There are different source of noise in digital image and video .Noise in the general spatial position and channel dependent. Bilateral filter takes the sum of the weighted average pixel. The weight are calculated depends on the both spatial and intensity difference in the images. Edge preserving smoothing as robust statistical estimation 0 order difference between the two intensity pixel [16]. The edge preserving stop function can be seen as the preventing the intensity pixel between the larger intensity value. Due to this type of filter, and its optimized hardware design presented in this work, the accuracy limits of hardware based stereo matching systems, is proposed while it also achieves real-time frame-rates for HD images.

4. PROPOSED MODIFIED GUIDED FILTER FOR REAL TIME VIDEO

This section initially describes the modified guided filter (MGF). Modified guided filter is used to remove noise preserve edges and also avoid halo effect in the NTSC real time video. Modified guided filter architecture, is implemented in hardware efficiently in a way that its logic resources are independent of the kernel radius *r*. NTSC video frame is 30 frames/sec. Modified Guided filter compute the filter output by calculating the content of guidance image's weighted pixel. It calculates the weighted pixel of the input noisy image and finds the difference between the noisy image and guidance image. Systolic array architecture is used to increase the speed of guided filtered. 9 stage pipeline architecture is proposed in this paper. The videos is converted into the sequence of frames and each frame is compared with the previous frame and the noise in the frame is found and this is called the optical flow of the frames. To implement the modified guided filter architecture on cyclone II FPGA device from the altera corporation.

A. Implementation for video sequence

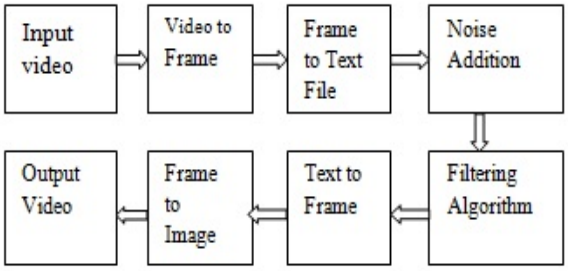


Figure-1. Implementation for video sequence.

a. Input video

The noisy video sequence containing the impulse noise is converted into the avi format because the avi format is uncompressed video format. Converted the video into the sequence of the frame.

b. Video to frame

Frames are extracted from the video sequence using the matlab code. Frames are converted into the hex file.

c. Noise addition

Adding the noise in the frame using the verilog code and apply the modified guided filter algorithm to remove noise preserve edges in the frame.

d. Output video

After completing the entire process, the processed are finally converted back into the original video.

B. Proposed module description

a. Input noisy video frame

In the sequence of video frames the first frame is consider as the input noisy video frame. Impulse noise is corrupted in the image the each value of the pixels are carries only the intensity information.

b. Register bank

Split the frame into 16 x16 macro block using the macro block conversion method and store the macro blocks into register bank. Register banks are consisting 9 registers is used to store the blocks.

c. Photometric component and geometric component:

The output of the photometric component the weighted pixel are appear still sorted into the group by the weighted mid_pix

1) Weighted pixel are sorted into the group of 0 to 5
2) Weighted pixel being filter by mid_pix

Geometric component is the explicit weighted average filter and the output of the geometric component weighted pixel are sorted into the group by the weighted mid_pix.

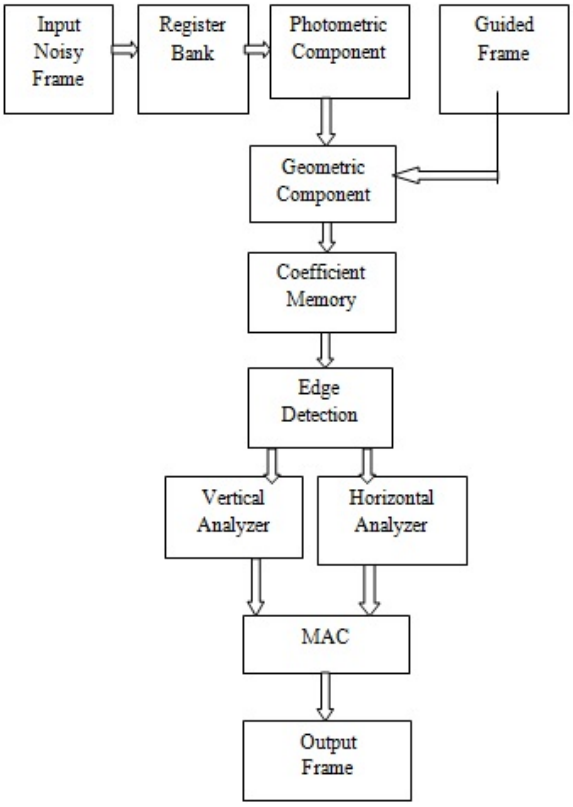


Figure-2. Block diagram of modified guided filter for video.

d. Edge detection

An edge is a boundary of sudden intensity change in the pixel level .In edges the halo effect appears and it is given to the vertical analyzer and horizontal analyzer. Vertical analyzer calculates the row wise pixel and horizontal analyzer calculates the column wise pixel. It avoids the halo effect using the weighted least filter is one of the implicit weighted average filter it calculate the matrix affinities as per image gradient level its produce a halo free edge preserving smoothing.

e. Image quality assessments

To check out the performance of noise reduction and accuracy of the edge preservation and criteria for the image quality.

$$PSNR=20\log_{10}(GVmax / \sqrt{MSE}) \quad (16)$$

Mean square error between the image to be compared and the reference image GV_{max} represent the maximum gray value depends on the image.

5. RESULTS AND DISCUSSIONS

The proposed modified guided filter is first simulated in Matlab. The proposed modified guided filter architecture is written in verilog hardware language, implemented and simulated on the Model sim 6.4. The Quartus II 9.0 tool is used to synthesize the designed

Modified guided filter and finally implemented on Altera DE2 -70 kit using cyclone II EP35F6C726.For the algorithm simulation in Matlab used a test video .This video is converted into the sequence of frames using Matlab. These frames are converted into the text file. The text image is given to the register bank store the image. The image text is converted to image and finally the video is obtained.

a. Input video frame 1

b. Input video frame 2

c. Noisy video frame 1

d. Filtered video frame 1

e. Noisy frame 2

f. Filtered frame 2

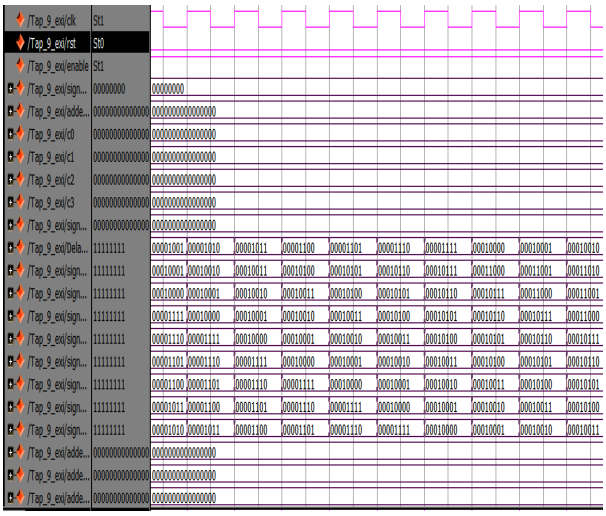
Table-1. The PSNR comparison for modified guided filter.

Input image	Bilateral filter	Guided filter
Frame 1	16.720 dB	16.770 dB
Frame 2	15.010 dB	15.113 dB

Table-2. The synthesis results of modified guided filter for video.

Architecture	Bilateral filter	Modified guided filter
FPGA device	EP35F6C726	EP35F6C726
Total logic element	690	436
Total logic register	533	310
Multiplier element	36	20
Maximum frequency	60.6 1 MHZ	148 Mhz

Simulation results of modified guided filter for video



6. CONCLUSIONS

This paper designed a modified guided filter architecture for real time videos. Digital images are very much essential for our daily life applications. Color videos/images are corrupted with the impulse noise which is induced from different digital cameras. So, a modified guided filter is implemented in cyclone II DE-2 board to remove the noise in video/image preserve the edges and also avoids the halo effect in videos

Modified guided filter offers better performance than bilateral filter in noise reduction and edge preservation for NTSC video It has the fast and non-approximate linear time algorithm In this work power and speed are calculated. The total area and delay a 436 logic gates and delay 0.0070ns.The maximum operation frequency for the systolic array architecture is 148 Mhz

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