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A Processor Based Technique with Multi scale Enhancement Algorithm for Extended Interpolation

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ABSTRACT : Through this work, a low complexity and an efficient DWT processor based design is proposed for image scaling application. The paper also introduces a high quality Frequency domain interpolation algorithm for the image scaling. This algorithm consists of a sharpening filter and a smoothing filter. Both the filters act as a pre filters to reduce the blurring and aliasing artifacts produced by the frequency domain technique. To enhance the speed for this proposed system, a serial architecture with partial pipelined structure is introduced along with good utilization in accomplished with resources availability in target FPGA. The new model is designed by System Generator blocks using the simulink Simulation. A Matlab tool along with Xilinx synthesis tool (XST) also used. The final results give the power consumption of 117mW at 28 degree/c in seam temperature. An improvement of speed in 15% with better Signal to noise ratio is obtained from the comparison result.

Keywords - Image Scaling, Frequency Domain, DCT, DFT, DWT.

1. INTRODUCTION

Now a day as the video and graphic properties of mobile devices growing up and thus the demand for Image Scaling is highly influencing. Using this Image Scaling application we can Scale down a high-quality video frames or picture to include in an accurate liquid crystal display panel of table PC or mobile Phone [4]. This is one of the main advantages of Image scaling. The same technique uses in now day's electronic devices like High-definition television, digital video recorders, mobile phone, digital camera, tablet PC etc [3]. Thus proposes the Frequency domain algorithm for image scaling application.

With the increasing use of multimedia technologies, image scaling requires higher performance. To tackle the requirements and needs of internet and multimedia applications, numerous competent image scaling techniques, with noticeably different properties, have been implemented [2]. Traditionally, image scaling adopts discrete cosine transform (DCT) in most situations which possess the characteristics of simpleness and practicality. One of the shortcomings is obvious blocking artifact and bad subjective quality when the images are restored by this method at the high compression ratios. In recent years, many studies have been made on wavelets. From those studies it can implies that what wavelets have given to the fields as wireless communication, computer graphics, and biomedical applications. Image scaling is one of the most evident applications of wavelets. The quick raise in the range and use of electronic imaging justifies attention for systematic design of an image scaling system and for given that the image quality needed in diverse applications .

Discrete Wavelet Transform is used as a core technology to scale images. It is multi-resolution analysis and it decomposes images into wavelet coefficients and scaling function. The signal energy is concentrate for specific wavelet coefficients in Discrete Wavelet Transform. To scale an image this feature is more useful. More research have been focused in recently based on DWT, these technique became an image scaling application standard tool due to the capability of data reduction. In DCT based scaling technique there uses a block by block object. But here in wavelet scaling method uses the single data object form transform and scaling. A uniform distribution of scaling error beyond the entire image is possible here. With high compression ratio, a better image quality can produced by these technique compare with DCT. Generally utilization of signal and reconstruction along with better analysis is done by Fourier Transform.

However, Fourier transform does not comprise any local information about the unique signal. So that, diminutive Time Fourier Transform has been introduced, this uniformly samples the time-frequency plane. The multi resolution nature of the discrete wavelet transform is proven as a powerful tool to represent images decomposed along the vertical and horizontal directions using the pyramidal multi resolution scheme. Discrete wavelet transform helps to test different allocations using sub-band coding, assuming that details at high resolution and diagonal directions are less visible to the human eye.

2. PROPOSED SCALING ALGORITHM

The frequency domain refers to the analysis of mathematical functions or signals with respect to frequency, rather than time. In electrical engineering these thoughts are also one of the theoretical pillars within the field. Along with all of the mathematical gear utilized in electrical engineering, frequency domain analysis is arguably the most far-reaching. In fact, these ideas are so important that they are extensively used in numerous fields – not just in electrical engineering, but in virtually all branches of engineering and science, and quite a few areas of mathematics.

The proposed scaling algorithm consists of a sharpening spatial filter, a smoothening filter and a frequency domain Interpolation. The sharpening spatial and smoothing filters serve as pre filters to reduce blurring and aliasing artifacts produced by the Frequency domain interpolation. Initially, the input pixels of the original images are filtered by the sharpening spatial filter to augment the edges and eliminate allied noise. Next, the filtered pixels are filtered again by the smoothing filter to smooth unwanted discontinuous edges of the periphery regions. At last, the pixels filtered by both of the sharpening spatial and clamp filters are conceded to the Frequency domain interpolation for up -/ down scaling [5].

2.1 Sharpening Spatial Filter

The sharpening spatial filter, a sort of high-pass filter, is used to diminish blurring artifacts and distinct by a kernel to increase the intensity of a center pixel relative to its neighboring pixels. The following expressions will illustrate the Sharpening Spatial filter operation, D0 origin of transform

$H_p(u,v) = 1-H_{lp}(u,v)$

$$H(u,v) = \begin{cases} 0, & if\ D(u,v) < D0 \\ 1, & if\ D(u,v) \geq D0 \end{cases} \quad (1)$$

2.2 Smoothing Filter

The smoothing filter, a sort of low-pass filter, is a Gaussian spatial 2-D domain filter and composed of a convolution kernel array [1]. It typically contains a solo positive value at the core and is completely bounded by ones. The smoothing filter is used to diminish aliasing artifacts and smooth the redundant discontinuous edges of the boundary regions. The sharpening spatial and smoothing filters can be represented by convolution kernels [5]. A better range of convolution kernel will construct higher quality of images. The operation for smoothing filter is given by

$$H(u,v) = \begin{cases} 0, if\ D0 < D(u,v) \\ 1, if\ D0 \geq D(u,v) \end{cases} \quad (2)$$

If image is of size MxN, center of the frequency rectangle is at (u,v)=(M/2,N/2)

$$D(u,v) = [(u-M/2)^2+(v-N/2)^2]^{1/2} \quad (3)$$

2.3 Simplified Frequency Domain Interpolation

The general idea for this technique is that the image (*f(x,y)* of size *M* x *N*) will be represented in the frequency domain (*F(u,v)*). The equation for the two-dimensional discrete Fourier transform (DFT) is given by

$$F(u,v) = \sum_{x=0}^{M-1} \sum_{y=0}^{N-1} f(x,y) e^{-j2\pi(ux/M+vy/N)} \quad (4)$$

The concept behind the Fourier transform is that any waveform that can be constructed with a sum of sine and cosine waves of diverse frequencies. Exponential in the beyond formula can be stretched into sines and cosines with the variables *u* and *v* formative these frequencies.

The converse of the beyond discrete Fourier transforms is given by the subsequent equation.

$$f(x,y) = \frac{1}{MN}\sum_{u=0}^{M-1}\sum_{v=0}^{N-1} F(u,v)e^{j2\pi(ux/M+vy/N)} \tag{5}$$

Hence, if we include *F(u,v)*, we can achieve the corresponding image (*f(x,y)*) using the inverse, discrete Fourier transform.

The operation of Frequency Domain Interpolation take place by Multiply the input image by $(-1)^{x+y}$ to center the transform. Then Compute F(u,v), the DFT of the image. After computing F(*u*,*v*) Multiply F(u,v) by a filter function H(u,v). After that Compute the inverse DFT of (3). Thus Obtain the real part of the result after that Multiply the result in (5) by $(-1)^{x+y}$

3. THE DISCRETE WAVELET TRANSFORM

The Discrete Wavelet Transform, which is based on sub-band coding, is originate to yield a rapid estimation of Wavelet Transform. It is simple to implement and reduces the calculation time and resources that is necessary. The discrete wavelet transform uses filter banks for the construction of the multi resolution time-frequency plane. Discrete Wavelet Transform analyzes the signal at diverse frequency bands with diverse resolutions by decomposing the signal into a detail information with an approximation. The two frequency bands are obtained after decomposition of signals are high pass g[n] and low passes h[n] filtering of the time domain signal. The both frequency will be different. A pair of analyzing filter is accomplished by the combination of these high pass g[n] and low pass h[n] filter. The final output is the half content of the frequency and which equals the amount of input sampling signal.

The two outputs together contain the same frequency content as the input signal; conversely the quantity of data is doubled. Consequently down sampling by a factor two, denoted by ↓ 2, is applied to the outputs of the filters in the scrutiny bank. Reconstruction of the original signal is possible using the synthesis filter bank. The signal are sampled up (↑ 2) and passed through the h[n] and g[n] filter in the synthesis bank. This is the process took places. The filters in the synthesis bank are based on the filters in the scrutiny bank [6]. Accurate choice of the combination of the analyzing filters and synthesizing filters will offer ideal reform. Ideal reform is defined by the output which is normally an estimate of the input, being precisely identical to the input applied. The breakdown process can be iterated with consecutive approximations being decayed in return, so that one signal is broken down into numerous lower-resolution components. Decomposition can be performed as ones requirement. The Two-Dimensional DWT (2D-DWT) is a multi level decomposition technique. It converts images from spatial domain to frequency domain. The one level of wavelet breakdown produces four filtered and sub-sampled images, referred to as sub bands.

4. PROPOSED DESIGN

The block diagram of the proposed design is shown in figure 1. It consists of a pair of exterior dual-port memories and a DWT processor. The two dual memories are initialized with the pixel values of a gray scale image. Within this projected design, input is provided to the DWT processor by importing an image from the workspace in Matlab. The DWT processor includes memory controller and crossbars and a DWT filter [6]. The crossbars are used for interleaving the image pixels i.e. the output of the high pass and low pass filter will be distributed alternatively to the two memory banks.

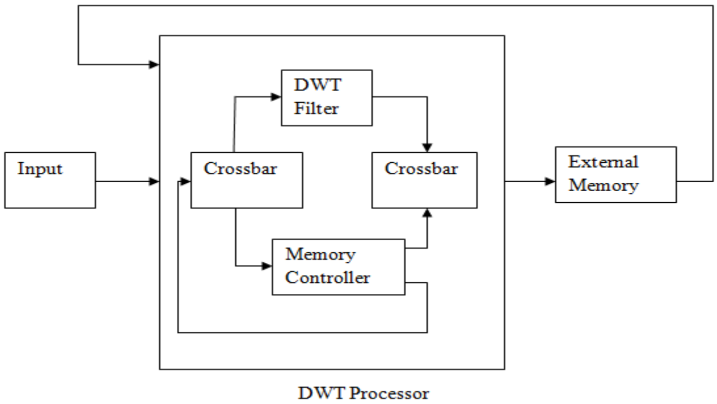

Fig.1 Block diagram of Proposed Design

A memory controller performs the read and writes operation simultaneously. The figure 2 illustrates the Memory Controller block diagram. It does not account for latency of getting data from memory or latency of the filter. The memory control signals are all derived from two counters which are free running. The reset holds the counts at nil until a start pulse arrives. The bulk of control is determined on per phase basis from the master counter. The number of phases is defined by the state register. Recombination of bits from master counter for every phase derives the address logic as well. Actually, the read addresses are just the count value -- i.e. the memory read for this phase is just a stride 1 loop through the whole memory bank. The write addresses for this phase repeat each address twice.

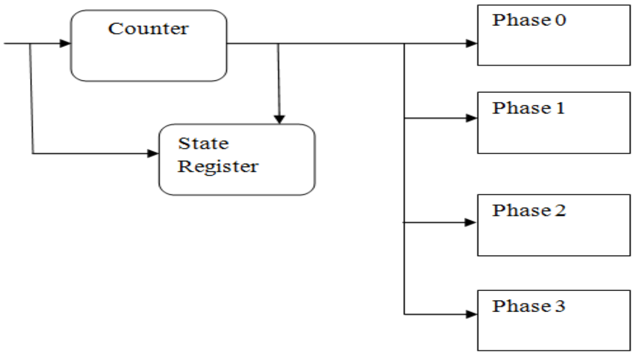

Fig.2 Memory Controller

The external memory bank where the write enable is asserted into variable selector block. The variable selector extracts a subset of rows from the input and fed the output to P1 and P2. These products P1 and P2 perform division and multiplication of its inputs and pass it through write inserter. The write inserter passes first or third input based on the value of second input and output is fed to the read section. Which shows one word is inserted to the definite address location of exterior memory bank and the part of read section picks up the appropriate word from the memory vector. In case of overlapping of address, the read is done prior to the write changes the stored word.

5. RESULTS AND DISCUSSION

The proposed model has designed and simulated using Simulink and Xilinx System Generator block sets. The simulated has been accomplished by using DWT filter in the projected model. To decompose the images into its detail and estimate information respectively, the DWT filter uses high pass filter and low pass filter. The figure 3 shows the breakdown of images or decomposition.

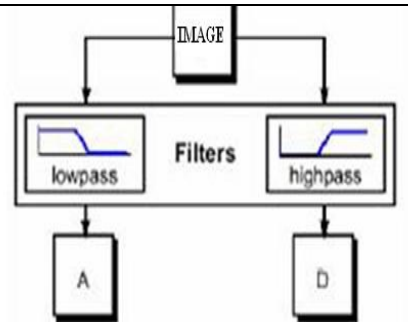

Fig.3 Decomposition Image

The decomposition process can be iterated with successive approximations being decomposed into many lower declaration gears. Wavelet decomposition tree which is the usual term described for this process. The iteration of the breakdown process is shown in figure 4.

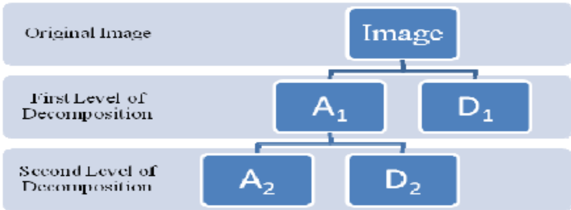

Fig. 4 Iteration of Decomposition Process

The total power consumption of the proposed design based has been calculated using XPower utility. It can be observed from the table I that proposed design has consumed 117mW at 28 degree C. The Table I show the power consumption in detailed.

TABLE I. Power Consumption

Name	Value	Used	Total Available	Utilization (%)
Clocks	0.01036 (W)	1	---	---
Logic	0.00069 (W)	333	9312	3.6
Signals	0.00187 (W)	569	---	---
IOs	0.02350 (W)	91	232	39.2
Total Quiescent Power	0.08144 (W)			
Total Dynamic Power	0.03641 (W)			
Total Power	0.11786 (W)			
Junction Temp	28.1 (degrees C)			

The pixels filtered by both of the sharpening spatial and clamp filters are passed to the Frequency domain interpolation for up -/ down scaling. Figure 5 shows the corresponding output using Matlab simulation.

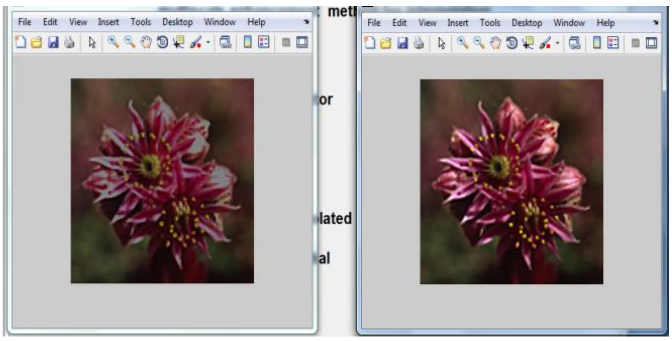

Fig.5 Frequency Domain Output

To be able to analyze the qualities of the scaled images by various scaling algorithms, a peak signal-to-noise ratio (PSNR) is used to quantify a noisy estimate of the refined and the unique images. While the maximum value of each pixel is 255, the PSNR articulated in dB can be calculated as

$$PSNR= \frac{MN \times 255^2}{10\log_{10} \sum_{m=0}^{M-1}\sum_{n=0}^{N-1}[P(i,j) - P'(i,j)]2} \quad (6)$$

Here N and M represents the height and width of the original image.

To show the quality of the images changed after using the smooth filter, sharp filter and the combined filter, the three kinds of PSNR results for this project are listed in Table II. In this table they listed as each test image should filtered by a fixed low pass filter and then scaled up/ down to different size such as common intermediate format , video graphic array and High definition Multimedia Interface.

Table II. Comparison of PSNR Averaging

	1	2	3	4	5	A	B	C
Half	27.04	27.30	28.15	27.42	28.49	27.68	27.77	28.27
CIF	27.80	27.75	28.70	27.82	29.25	28.39	27.83	28.22
VGA	28.50	28.55	28.92	28.58	29.44	28.54	28.42	28.60
DI	28.50	28.51	28.92	28.55	29.24	28.56	28.25	28.61
Doub.	28.50	28.52	28.97	28.58	29.37	27.87	28.80	28.78
HDMI	28.56	26.94	28.96	26.96	29.38	28.72	28.66	28.76
Ave.	28.15	27.93	28.77	27.99	29.20	28.29	28.32	28.54

A. Using sharpening Filter and Frequency Domain Interpolation, **B**. Using Smooth filter and Frequency Domain Interpolation, **C**. Using Combined filter and Frequency Domain Interpolation

6. CONCLUSION

In this paper, a low complexity and an efficient DWT processor based Image Scaling model has been offered. The partially pipelined serial architecture is introduced to improve the speed and area competence. The projected design can function at a maximum frequency of 231 MHz by consuming of 117mW power at 28^{o}C seam temperature. It preserves fine detail better than the common Scaling algorithm. With added adaptive skill, the quality of the resulting scaled images is notably improved.

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