WAVELET BASED IMAGE FUSION USING FPGA FOR BIOMEDICAL APPLICATION

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Abstract - *An emerging concept of hardware co-simulation using MATLAB and Xilinx System Generator for implementation of wavelet based image fusion is presented in this research work. This research work presents a flexible system for image fusion algorithms for gray scale images by using as few as possible System Generator Blocks. Performance of this system implemented on FPGA board Virtex6 XC6V-LX240T prototype. This research work presents DWT, implemented with the filter banks whose levels can be adjusted. The perfect reconstruction can be obtained with the down sampling of the images. Wavelet decomposition provides a simple hierarchical frame work to fuse images with different spatial resolution. Discrete wavelet transformation is presented concisely for the understanding of the wavelet based image fusion method. To best retain the quality of the input images, a strategy that is flexible enough to minimize the necessary operations to limit potential image quality deterioration is proposed. In the proposed fusion approach, the wavelet coefficients for the fused images are selected based on the suggested maximum magnitude criterion. Our results clearly suggest that the wavelet based fusion can yield superior properties to other existing methods in terms of both spatial and spectral resolutions, and their visual appearance.*

Key Words: Wavelet, Xilinx system generator (XSG), Simulink, field-programmable gate arrays (FPGAs) etc.

1. INTRODUCTION

Images are the most common and convenient means of conveying or transmitting information. About 75% of the information received by human is in pictorial form. These images are represented in digital form. An image may be defined as a two-dimensional function, f(x, y), where x and y are spatial (plane) coordinates, and the amplitude of at any pair of coordinates (x, y) is called the Intensity or gray level of the image at that point. When x, y, and the amplitude values of f are all finite, discrete quantities, we call the image a digital image [6],[7][8],[9],[10].

Image fusion means the combining of two images into a single image that has the maximum information content without producing details that are non-existent in the given images. With rapid advancements in technology, it is now possible to obtain information from multi source images to produce a high quality fused image with spatial and spectral information. Image Fusion is a mechanism to improve the quality of information from a set of images [12],[13],[15]. Important applications of the fusion of images include medical imaging, microscopic imaging, remote sensing, computer vision, and robotics.

Wavelet Transforms can be used for multi-resolution image fusion at pixel level, as they work both in spatial and spectral domains and result in the preservation of spatial of spectral details of input images [14].

The most widespread enabling technology for these kinds of implementations is the so-called field-programmable gate arrays (FPGAs). Modern versions of these devices offer a number of critical characteristics such as large number of logic elements to allow the implementation of complex algorithms, very large scale integration to occupy minimum space, low power consumption, and very high speed grades. Therefore, system implementations can be real time, mobile, robust, and low-power consuming [1],[3],[4],[5],[11].

2. PROPOSED SYSTEM

2.1 The Pyramid Algorithm

The image pyramid is a data structure designed to support efficient scaled convolution through reduced image representation. It includes a sequence of number of an original image in which both sample density and resolution are decreased in regular steps. It is obtained through a highly efficient iterative algorithm. The bottom or zero level of pyramid G0 is equivalent to the original image. To obtain the next pyramid level, low pass-filtered and sub sampled by a factored by two G1.It is then filtered in the same way and sub sampled to obtain G2. Further repetitions of the filter/subsample steps are applied to generate the remaining pyramid levels [2]. The pyramid structure is used for supporting scaled image analysis. Pyramid structure of decomposed signal shown in Figure 1.

The pyramid algorithm operates on a finite set of N input data, where N is a power of two; this value will be referred to as the input block size. These data are passed through two Convolution functions, each of which creates an output stream that is half the length of the original input. These convolution functions are filters; one half of the output is produced by the low-pass filter function, related to equation,

$$a_i = \frac{1}{2}\sum_{j=1}^{N} C_{2i} - j + 1f_i \qquad i = 1, \dots\dots\dots, \frac{N}{2} \qquad \text{--- (1)}$$

other half is produced by the high-pass filter function, related to equation,

$$b_i = \frac{1}{2}\sum_{j=1}^{N}(-1)^{j+1}\ C_j\ + 2 - 2_i \qquad i = 1, \dots \dots \dots, \frac{N}{2}$$

--- (2)

Where N is the input block size, c is the coefficients, f is the input function, and a and b are the output functions.

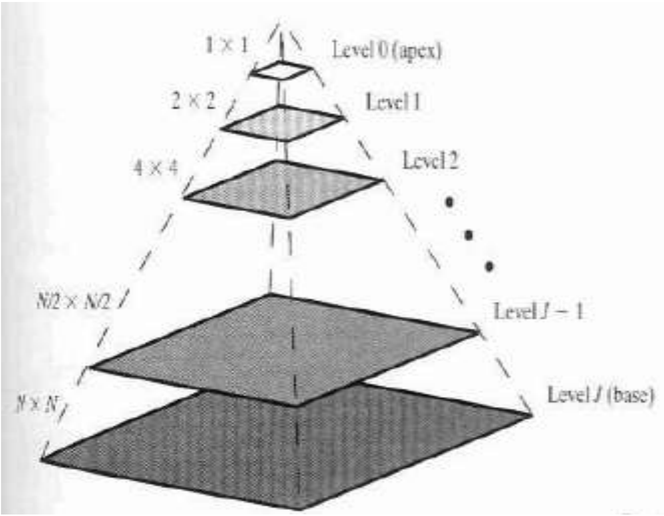


Fig -1: Pyramid structure of decomposed signal.

2.2 Image fusion

The basic aim of image fusion is to represent relevant information from multiple images. Some fusion methods may represent important visual information more adversely as compare to [8],[9],[10]. Image Fusion is a process of combining the relevant information due to this resultant fused image will provide more information. Image fusion techniques can improve the quality and increase the application of these data [6],[7]. In spatial domain techniques, we consider only image pixels.

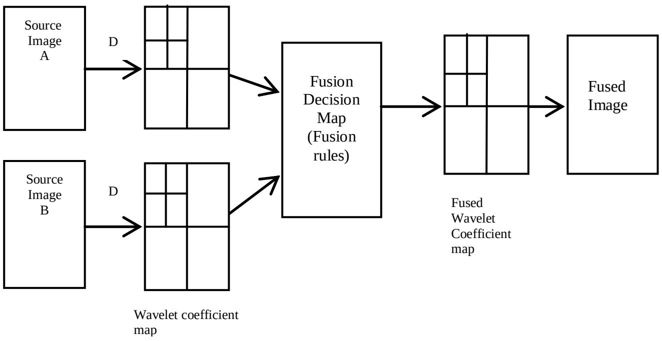


Fig – 2: Image fusion using DWT.

The pixel values are manipulated to achieve desired result. In frequency domain methods the image is first transferred in to frequency domain. All the Fusion operations are performed on the Wavelet Transform of the image and then the Inverse wavelet transform is performed to get the resultant image [12],[13],[14]. Image fusion using DWT which shown in Figure 2.

3. IMPLEMENTATION TECHNIQUES

For implementation MATLAB R2013b with Simulink is used. The overall design is implemented as shown in figure below- Figure 3.

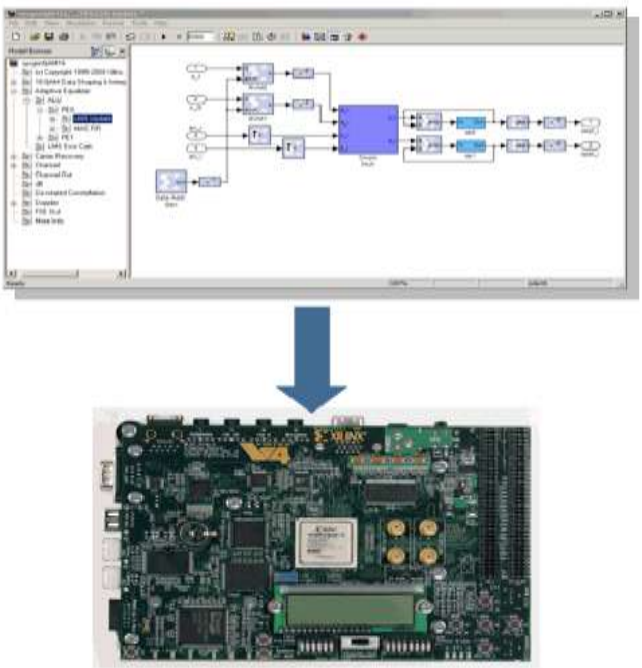


Fig -3: Hardware Co-simulation using System Generator Tool.

Steps to design Simulink model on FPGA platform are as given below:

1. Build the model with Xilinx blockset such as IN and OUT block.
2. After adding required block Simulink model is as shown in figure 4.

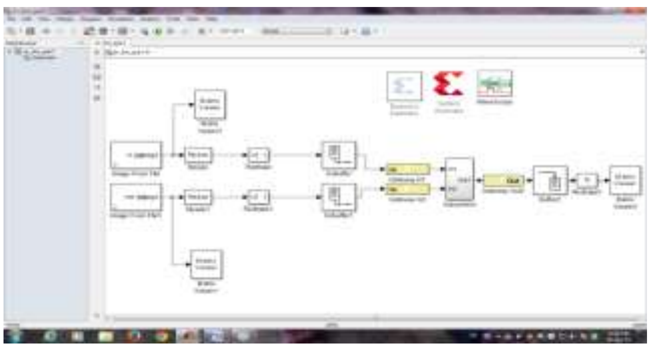


Fig – 4: Simulink Model using System Generator Tool

3. For implementation of Image Fusion with Simulink model on vertex XC6vlx240t.
4. When system generator Description Builder opens. Write the name of FGPA device, Clock Frequency of Vertex 6 XC6vlx240t is 33MHz. Write the location of Global clock pin

as AE16. JTAG option is chosen for communication in between FPGA device and Simulink model.

5. Click on detect then, it detect the length of instruction register. Click on add the device from the list as shown in Figure 5.

Fig – 5: Adding the Vertex 6 XC6vlx240t device

6. Click on save files. It installs the Spartan Vertex6 board plug-in into Matlab files. Completion of installation massage is given.

7. Now Vertex 6 board is added. For hardware co-simulation on system generator token select the hardware co-simulation. From that select the required board such as Vertex 6.

8. When compilation completely finished, it create the hardware co-simulation JTAG block.

9. Copy the JTAG co-simulation into Simulink model as shown below-

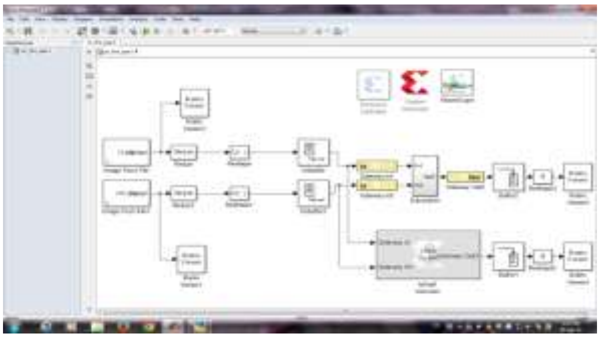


Fig – 6: Simulink model for hardware co-simulation

10. For hardware co-simulation hardware setup as shown in figure 6 is done. In that plug the powers supply of VERTEX 6 FPGA starter kit. Connect the USB port to computer. Put the device in JTAG configuration.

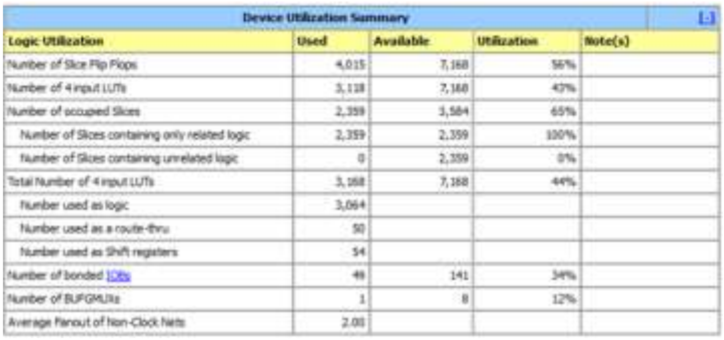
4. RESULTS AND DISCUSSION

The Image fusion design is implemented with the two input image on which following results are obtained. The MATLAB Simulink model of Image fusion model is given in above figure 6. Image fusion is obtained using the averaging method the mean value is calculated of two different images after the decomposition of images. The algorithms are developed and models are built for image fusion application using wavelet decomposition these models are simulated in Matlab Simulink environment with suitable simulation time and simulation mode. The reflected results can be seen on a video display. The results of the image fusion based on the wavelet decomposition algorithm as shown in the figure 7.

Fig -7: Simulation Result with two input images and fused image.

The input images are the medical images MRI and CT respectively. MRI captures nerves and small tissues whereas CT image captures the bones so this complementary information can be fused together to obtain the composite fused image. The fused image is having the resolution as per the variable size which is designed using resize block.

After synthesis of designed fusion model, the synthesis report shows the resources required for the design which are less enough and efficient. The snap shot of resource utilization and synthesis report for Image fusion model is as shown in Figure 8.



Device Utilization Summary

Logic Utilization	Used	Available	Utilization	Note(s)
Number of Slice Flip Flops	4,015	7,168	56%	
Number of 4 input LUTs	3,118	7,168	43%	
Number of occupied Slices	2,359	3,584	65%	
Number of Slices containing only related logic	2,359	2,359	100%	
Number of Slices containing unrelated logic	0	2,359	0%	
Total Number of 4 input LUTs	3,168	7,168	44%	
Number used as logic	3,064			
Number used as a route-thru	50			
Number used as Shift registers	54			
Number of bonded IOBs	49	141	34%	
Number of BUFGMUXs	1	8	12%	
Average Fanout of Non-Clock Nets	2.00			

Fig – 8: Device Utilization Report of Image fusion model on Vertex 6 XC6vlx240t development board.

System generator design using simulink which match with hardware. Timing and Power analysis will generate the timing, and power utilization report for the particular design. Snapshots of Timing Analyzer and Power Analyzer for Image Fusion Model shown in Figure9 &10.

Fig – 9: Timing Analysis of Image fusion model on Vertex 6 XC6vlx240t development board.

Fig – 10: Power Analysis of Image fusion model design on Vertex 6 XC6vlx240t development board

As per the above results, the image fusion model design requires less power i.e 0.1W

5. CONCLUSION

In this proposed architecture is constructed using a prototyping environment with MATLAB-Simulink and Xilinx System Generator tool. A flexible system for image fusion is designed using pyramid decomposition algorithm. The designed system is optimum as it uses as few as possible System Generator Blocks. This system is successfully implemented on FPGA board i.e. Virtex6 XC6V-LX240T.The result given in this work proves that the proposed hardware implementation of enhanced Wavelet based image fusion model gives optimal result for biomedical image. Thus this proposed architecture is very well suited for image fusion using FPGA for biomedical image processing applications.

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