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VLSI Architecture for Multi-Band Wavelet Transform based Image Compression and Image Reconstruction

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Abstract: In this research, the Multi-band wavelet transform based Image compression and Image reconstruction is designed and implemented in terms of VLSI design environment. Wavelet transform is one of the main parts of the compression and reconstructions. The multiband wavelet transform is used instead of the conventional wavelet transforms. By using the multi-band wavelet transform, the image resolution is efficient and the requirements of the filters are minimum compare than the conventional transform based image compression. Image reconstruction is used to recover the original image from the compressed coefficients for the efficient image processing. The conventional method for image reconstruction is required the entire sub bands for reconstruction process. Multi-band wavelet transform based image compression is mainly used to reduce the number of redundant bits utilization as well as the better image resolution is highly achieved by using the multiband wavelet transform. The image is compressed in terms of MATLAB design environment and also the wavelet transform is performed by using VLSI design environment. The number of filter used is mainly decreased by using multiband wavelet transform based image compression and also the requirement of the interpolation filters are eliminated by using the image reconstruction.

Key words: Very large scale integration, multi-band wavelet transform, image compression, image reconstruction, filters, interpolation filters

INTRODUCTION

Discrete Wavelet Transform (DWT) is the important process in image processing. It is used for image compression, reconstruction, segmentation, enhancement, etc. Image compression and reconstruction is widely used in many type of applications. The wavelet coefficients of the some sub-bands have information; likewise the wavelet coefficient of other sub-bands does not have any kind of information. It will store the storage space of the image. The frequency components present in the wavelet transform are forwarded to the output after scaling the coefficient factors. The other frequency component in the process is attenuated. Image reconstruction is done by up-sampling followed by the process of filtering operation. Image reconstruction is used to reconstruct the 2D and 3D images using the certain algorithm. The reconstruction of image is the common technique used in the following technology like CT, MRI and PET scans to get a clear image. It is not only for scans also used in biology, earth science, medicine, etc. to find the exact in the image. Image reconstruction is not an easy; it has some difficulties to process the image and get the original image. Mostly the problem of reconstruction is noise, it interrupt the image and reduce the clarity of the output image. The noise in the image can be removed by using filters. Iterative reconstruction is the popular algorithm to reconstruct the 2D and 3D images. Iterative reconstruction is directly calculates the image within a single reconstruction step. The main advantages of this reconstruction is improved the insensitivity and capability of the reconstructed image. Image reconstruction using multi-band wavelet coefficient is used for reducing the hardware complexity during the image processing in the hardware components.

Literature review: Xiang *et al.* (2007) have been proposed the concept super resolution reconstruction of image sequences with Discrete Wavelet Transform (DWT) for produce a high resolution images in spatial domain. It is directly applied to the compressed videos without any quantization errors. The proposed concept was designed for both video and images. Image compression is done by using DWT technique. The image compression and reconstruction follows the theory named as Projection Onto Convex Sets (POCS) with new projection operator, it is purely based on DWT. It is also applied to remove the ringing noise from the restored images. DWT based POCS technique is effectively reducing the blurring artifacts and also used to create the high resolution images from various frames.

Akbarzadeh *et al.* (2015) presented the concept of single image super resolution algorithm, it is purely depends on wavelet transform. It is developed by using

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compensate the information losses during the time of image compression and reconstruction. The researcher proposed the technique named as Stationary Wavelet Transform (SWT) and inverse stationary wavelet transform for image reconstruction. These provide better results than the conventional methods for image reconstruction without increasing the size of the image. The extra bi-cubic interpolation is used in the technique for achieve a better results. The bi-cubic technique is not used in the conventional method. Finally, if provide the results as high resolution image from the low resolution image without increasing the image size and also it offers more speed than the other reconstruction methods.

Zhang *et al*. (2014) described the concept of image reconstruction based on single-level DWT. In general wavelet transform is used for compressed sensing and to improve the quality of image reconstruction. The researcher proposed the two methods named as row-column average method and threshold method. Row-column method is used to process the row and column vectors of coefficient matrices. The row and column vectors are processed one by one to get a reconstructed image. In the method to get two separate reconstructed image at last take average of two images to get a final results. Threshold method is used to improve the sparsity of two vectors. HLI, LHI and HHI are the vectors to set a threshold level for these vectors if the vectors is less than the threshold value, it will be set to zero.

Carvajal *et al*. (2016) have been proposed the concept image reconstruction in complex media using 4th moment wavelet. In general image processing uses Discrete Wavelet Transform (DWT) for compressing or filtering the images. DWT (Ye and Hou, 2015; Makbol *et al*., 2016) operation follows the concept of quadrature mirror filter used to analyze the image in different frequency component. The original images can be split up into different images with different set of frequencies. The sub-images are obtained from Low pass filter and Low pass filter (LL), Low pass filter and High pass filter (LH), High pass filter and Low pass filter (HL), High pass filter and High pass filter (HH). Normally the sub-images contain zero noise but the image sent via the wireless channel some of noise added to the image and change the nature of the original sub image. The noise in the image can be removed by using the above designed filters. Multi-band wavelet transform is used in many computer vision applications which is discussed by. Image fusion with perfect reconstruction DFT/RDFT filter banks and DWT is described by Ersoy (2006).

Image compression and reconstruction: Discrete Wavelet Transform (DWT) (Vakili and Khalili, 2015) plays an important role in image processing like compression and reconstruction. DWT is the process of convert discrete time signal into discrete wavelet representation. Image compression is a process of data compression; it is applicable for all digital images. The main aim of image compression is to reduce the storage space. Image compression divided into two types, these are lossless image compression and lossy image compression. Lossless image compression is digitally identical to the original image. It is preferred for medical imaging, comic etc. Lossy image compression method is ignoring the redundant component of the signal. The signal is changed according to the inputs. Digital image reconstruction technique is mostly used for creating the 2D and 3D images from the single dimension image. It is very useful for medicine, biology material science etc. Main drawback of the reconstruction is loss of information; the image is reconstructed from one form to another. It also takes more memory space.

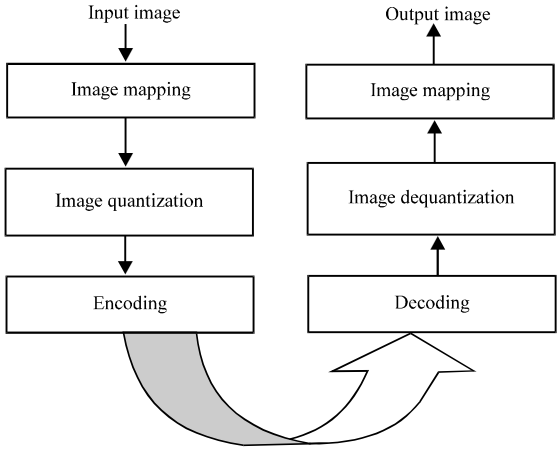

Fig. 1: General image compression flow diagram

Multi-band wavelet transform based image compression: Image compression is used to decrease the amount of data required for the representations of the audio or video file. These compression is only reduce the amount of data requirement, it not affect the original quality of the input given image or audio file. Image compression is highly used to store the data and efficient transmission and also the redundancy of the given image is highly reduced by using the image compression. An image representation requires minimum number of bits compared to the original given image. Since, the requirement of the memory storage is minimized and also the various images are to be stored at a time. These images are transformed at faster compare than the original image. There are three types of redundancies are available in the general Image compression. That is coding redundancy, inter-pixel redundancy and psycho visual system (Fig. 1).

MATERIALS AND METHODS

In traditional wavelet transform, the images compressed by using the high pass and low pass filters and vice versa. Sub sampling is also required for the conventional wavelet transform. By using the conventional method, the frequency resolution is highly affected at low and high frequencies. Then the utilizations of the high pass and low pass filter is increase the requirement of the filters. The multiband wavelet transform is proposed to overcome the limitations of the conventional wavelet transformations. In multiband wavelet transform, there are four types of the sub bands are used for the decomposition of the image. These types are approximation sub-band, horizontal and vertical sub-band and diagonal band.

Coding redundancy: The simultaneously symbols presence is represented by the some bits of the input given image.

Inter-pixel redundancy: The adjacent pixels are having the same value almost.

Psycho-visual redundancy: The various colors variations cannot differentiate by the human systems (Fig. 2). By using the Multi-band wavelet transforms, the resolution of the frequency is better compare than the other frequency bands. The sampling theorem is used to establish the down sampling rate.

The filter block is used to divide the total spectrum by the D-bands. The divided D-bands are having the same appropriate frequencies within the range. Then, the output is sub sampled by the D-factor. The output bands are given to the various wavelet transforms. The coefficient of the output sequences are having the minimum amplitude and the amplitudes are ignored for the image reconstruction. Since, the maximum images are having the least amplitude values for the compression. The requirements of the filters are illustrated in Table 1.

Image reconstruction using multiband wavelet transform: Image reconstruction is the process of creating an image using the raw data. In general image reconstruction is done by using up sampling followed by filtering operation. Up sampling is the process of sampling the time signal to provide the wavelet coefficients. The process of time signal to wavelet transforms generates some unwanted frequency components. It can be eliminated by using filters. In the conventional image reconstruction method named as multi-resolution wavelet transform, it has large hardware complexity and also need large space for storing the intermediate values. Also creates more delay to generate the reconstructed output,

Table 1: Requirements of the filters

Analysis for multi-resolutions	Analysis for multiband wavelet transform	Filters reductions (D)
2	D	2
4	D	6
8	D	14
16	D	30

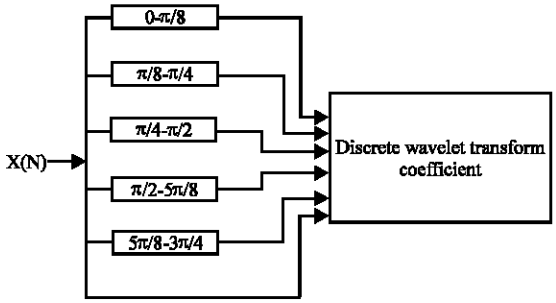

Fig. 2: Multi-band wavelet transform analysis

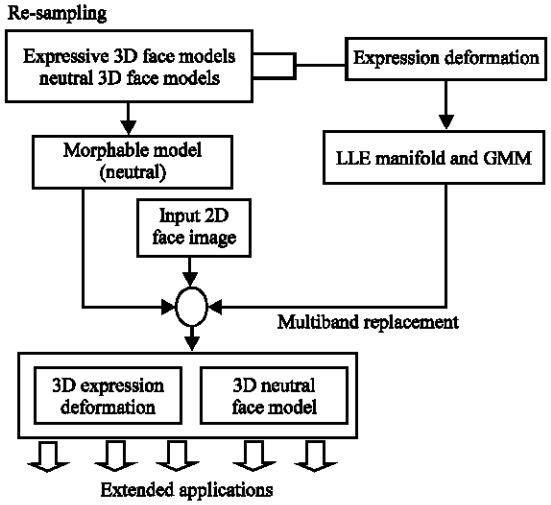

Fig. 3: General process of image reconstruction

throughput of the image is also low in the multi-resolution technique. To overcome the drawback by using multiband wavelet transform based reconstruction. Proposed multiband wavelet transforms avoiding the overlap of the frequency component. In the technique the wavelet coefficients are easily reconstructed by using summation filters. It is a common type of filter constructed by using parallel/sequential methods. It converts low resolution image into high resolution image using the multiband wavelet transform. Advantages of the proposed technique are to provide many more information of images. Improving the contrast and intensity of the image. Also remove the external noise occurred the image. General structure of image reconstruction is shown in Fig. 3.

RESULTS AND DISCUSSION

The image compression by using the multiband wavelet transform is implemented by using the Modelsim XE and MATLAB. MATLAB is used to read the input given image file and the compression is achieved by using the multiband wavelet transform. By using the multiband wavelet transform, the image resolution is better than the conventional image compression method. The compressed input image pixels are stored in the matrix then the matrix is used for the final stage of the VLSI implementations. The input image and output image of the proposed image compression is shown in Fig. 4.

The simulated output of DWT based multiband wavelet transform and different frequency bands generated by the filters are shown in Fig. 5 and 6 (Table 2).

Fig. 4: Input and output images of the multi-band wavelet based compressed image

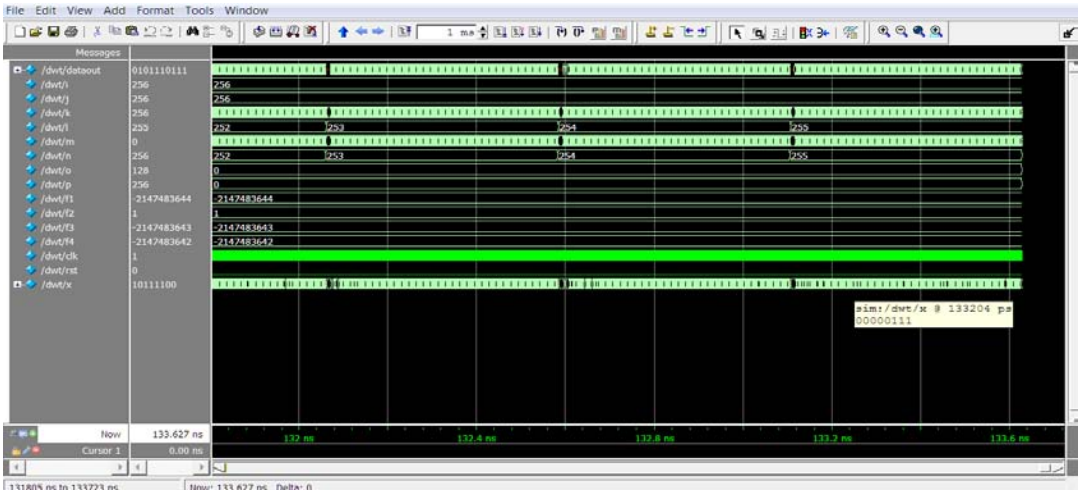

Fig. 5: DWT multiband wavelet transform

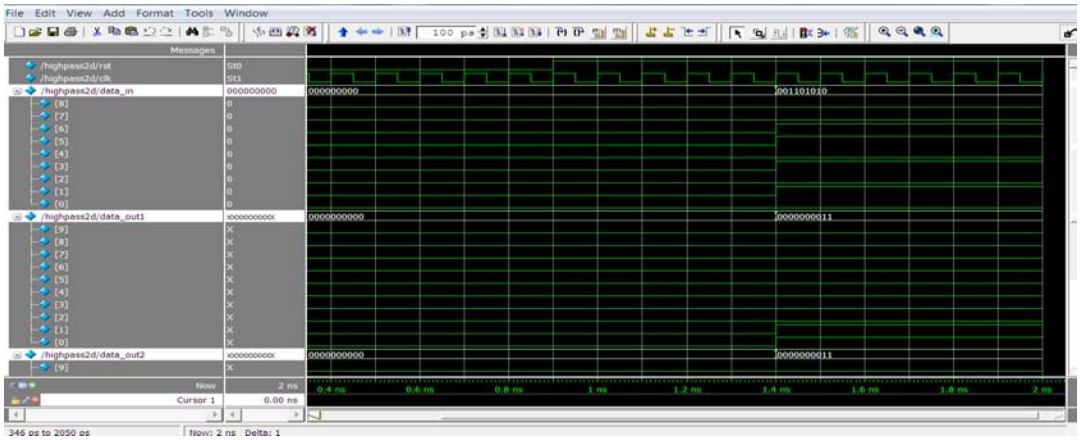

Fig. 6: Different frequency bands generated by filters

Table 2: Comparison of device utilization between two methods

Parameters	Multi-resolution wavelet analysis	Multi-bandwavelet analysis
LUTs	24	20
Occupied slices	30	28
Delay (NS)	3.71^{NS}	3.6^{NS}

CONCLUSION

Multi-band wavelet transform based image compression and reconstruction was designed. The proposed compression and reconstruction method is done through very large scale integration technique. Because have to find the hardware utilization and time taken for reconstruction process. Proposed multiband wavelet transform provide non overlapping frequency bands from the input images. There is no overlapping in the frequency bands image is easily reconstructed without any disturbance and also no need of interpolation filters. It uses only the summing filter for reconstruction. It offers 17% reduction in LUTs and 7% reduction in slices also 3% reduction in delay of the reconstruction and compression methods.

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