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# Image Reconstruction Using Wavelet Transforms and Curve Let Transform

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***Abstract:*** Digital signal processing relies heavily on linear transformations and expansions. Compression and denoising are two examples of signal processing applications where the wavelet transform has since proved useful. Instead of appropriately representing images with edges, the Wavelet Transform considers them as smooth functions with discontinuities along the curve. With the Curve let transform, frame components are indexed according to their scale, position, and orientation instead of the wavelet transform. They are scaled in line with an exclusive scalability rule, which specifies that a frame element's support's length is directly proportionate to its width squared. Image processing as well as communication technology like smartphones and tablets have been greatly influenced by it in recent years.

***Keywords**:* Wavelet Transform, Curve let transform

## I. Introduction

These Digital images an analysis processes include identity, authorization, and authentication. It's also possible to authenticate content by using fragile watermarking or semi fragile watermarking. Digital signatures and cryptography with key distribution as a form of symmetry or asymmetry authentication are further options. Images may be mined for useful information using the Wavelet transform technique, which allows for multi-resolution picture analysis. Understanding wavelets requires knowledge of linear algebra and signal processing. This software handles image compression, de-noising, and watermarking. Wavelets may convey several Transform image resolutions. To improve and restore an image or to segment an image for object identification or to compress an image, "Digital Image Processing" processes like image acquisition, 2-D signal (image), space-domain spatial domain spatial domain frequency-domain spatial domain may be employed in Figure1. Many digital image processing methods are illustrated in the picture, such as image acquisition, 2-D signals (pictures), spatial and frequency-domain image enhancement and restoration, image segmentation and object detection and compression, are employed throughout the imaging process.

In a traditional wavelet transform, the picture is sub-sampled after being processed through specifically designed high- and low-pass filters. Either the frequency resolution or the spectral efficiency of this approach are subpar. In other words, if high frequency resolution is beneficial, low frequency resolution is bad, and the reverse is also true when both high pass and low pass filters are utilized, a significant number of filters are needed. Wavelet transforms based on multiband analysis and synthesis filter banks are presented as a solution to this challenge.

## II. Concept and Methodology

To recover the original picture, the images must be filtered out. To begin, a one-dimensional filter is applied vertically down the row of pixels to each image. After one-dimensional filtering, a portion of the periodic picture subset is eliminated from the spectrum. Column-wise application of the same one-dimensional filter removes the remaining periodic images from the spectrum.

### Multilevel Thresholding

The image filtering equation with a particular kernel is as shown in below equation 1

$$f[x,y]*g[x,y] \;=\; \sum_{n_1=-\infty}^{\infty}\sum_{n_2=-\infty}^{\infty} f[n_1,n_2]\cdot g[x-n_1,y-n_2]$$

(1)

Some binary thresholding techniques can be adapted to function with more than two clusters [RRK84, KI86]. The mixture modeling approach extends easily, because it models a histogram as a blend of distributions, choosing thresholds at the valleys between the peaks of distributions. Equation 2 gives the general form of a mixture model with $k$ classes. The $\pi_i$S are the mixing weights which must sum to unity, $g_i(\cdot)$ is the distribution function for class $i$, and $\vec{\theta}_i$ holds the parameters of distribution $i$.

$$h(x) = \sum_{i=1}^{k} \pi_i \cdot g_i(x; \vec{\theta}_i) \qquad (2)$$

There are two kinds of compressed images: lossy compression and lossless compression. Wavelet co-efficient are the technical term for the pixels that make up the picture. Detailed and average coefficients make up the compressed picture. Similar parts of the picture have average coefficients, therefore the differential coefficients are 0 for the corresponding pixels. Thus, if the coefficients are tiny enough, encoding them requires no encoding at all or just the smallest amount of bits. Image compression using wavelet transform is built on top of this. This is shown in Figure.1 by using the forward wavelet transform.

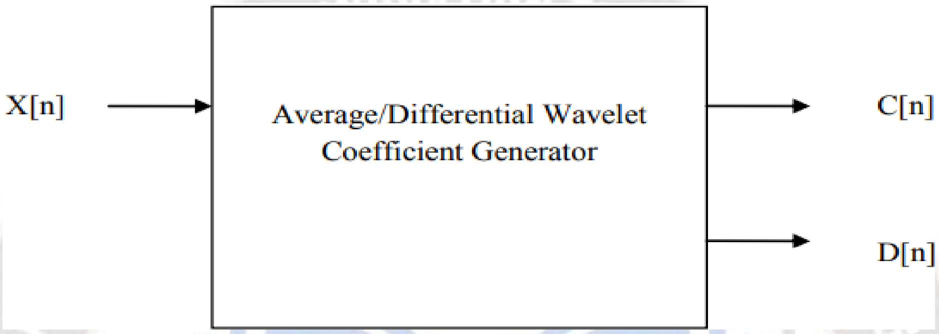


Figure.1 Generation of Wavelet Coefficients both average and detail

In the above diagram, X[n] represents the input samples and C[n] is the average coefficients of the input samples. The D[n] represents the detailed coefficients. The equation for C[n] and D[n] as a function of the input sample is given in Equation 1 and Equation 4.

$$c[n] = 0.5x[2n] + 0.5x[2n+1] \qquad (4)$$

$$d[n] = 0.5x[2n] - 0.5x[2n+1] \qquad (5)$$

The average coefficients and the detail coefficients can be used to reconstruct the original image using Equation 5 and Equation 6.

$$x[2n] = c[n] + d[n] \qquad (6)$$

$$x[2n+1] = c[n] - d[n] \qquad (7)$$

The reconstruction of sparse image from image wavelet coefficient structure is shown in figure 1.

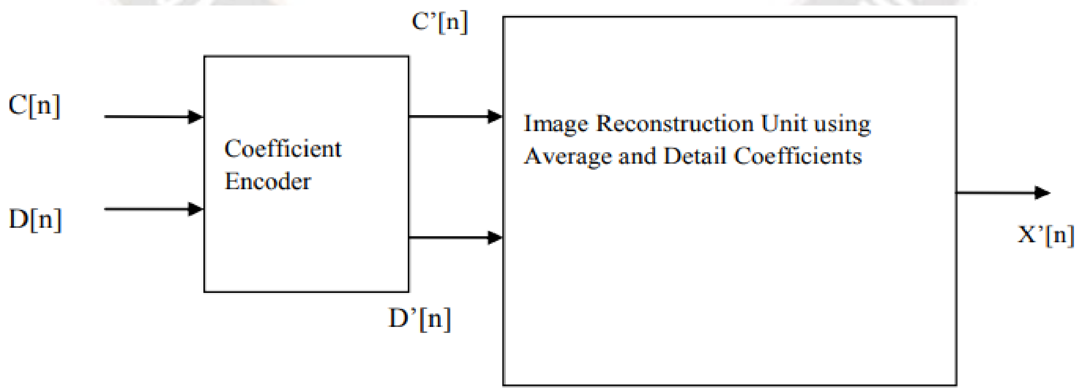


Figure.1 Reconstruction of Sparse Image from Wavelet Coefficients

It is clear from the above block diagram, as the number of decomposition levels increase, the decomposition units or filters also increase logarithmically. The wavelet transform units also occupy a significant chip area.

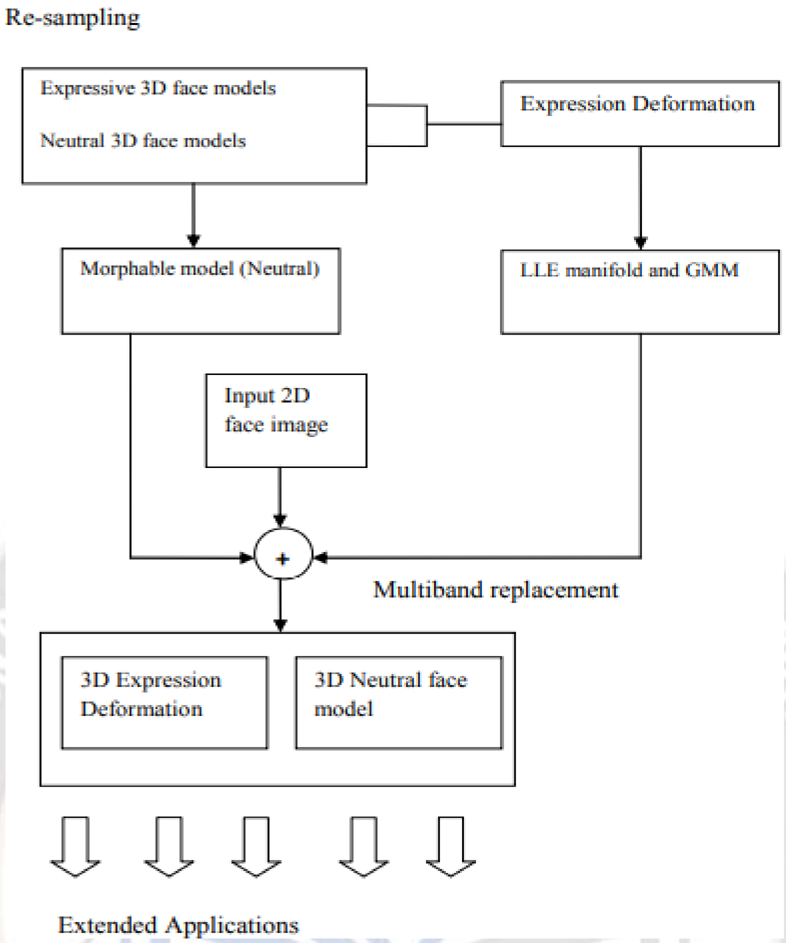


Figure.2 General Process of Image Reconstruction

Also creates more delay to generate the reconstructed output, throughput of the image is also low in the multi-resolution technique. The drawback can been overcome 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. It improves the contrast and intensity of the image. Also remove the external noise occurred in the image. General structure of image reconstruction is shown in figure 2.

### III. Image Reconstruction Using Proposed Technique

The frequency component of Multi Band Wavelet Analysis does not overlap with each other. Hence instead of using complicated filters the image encoded using Multiband Wavelet Transform Coefficients can be easily reconstructed using summation filters. The summation filters can be implemented using parallel or sequential methods. The hardware required to implement the summation filters in parallel and sequential is shown in Table 1 and Table 2 respectively.

Table 1 Summing Filters required for Parallel Reconstruction for a down Sampling Factor D

| Stage Number | Multiresolution Wavelet Analysis Reconstruction | Multiband Wavelet Analysis Reconstruction | Reduction in Number of Filters |
|---|---|---|---|
| 1 | 2 | D-1 | 3-D |
| 2 | 4 | D-1 | 5-D |

| | | | |
|---|---|---|---|
| 3 | 8 | D-1 | 15-D |
| 4 | 16 | D-1 | 31-D |
| 5 | 32 | D-1 | 63-D |

It is clear from Table 1 that whatever may be the image resolution the number of summing filters required is always one less than the number of bands or the down sampling factor. If the same hardware is implemented sequentially, only one summing filter is required always.

Table 2 Summing Filters required for Sequential Reconstruction for any down Sampling Factor

| Stage Number | Multi-resolution Wavelet Analysis Reconstruction | Multiband Wavelet Analysis Reconstruction | Reduction in Number of Filters |
|---|---|---|---|
| 1 | 2 | 1 | 1 |
| 2 | 4 | 1 | 5 |
| 3 | 8 | 1 | 13 |
| 4 | 16 | 1 | 29 |
| 5 | 32 | 1 | 61 |

## IV. Conclusion

It is inferred that the conventional reconstruction method has large hardware complexity. It requires large memory for storing the intermediate values. The latency is high and the throughput is low. In order to overcome the problem Image Reconstruction using Multiband, Wavelet Coefficients is proposed in this paper. In the existing method of Multi Resolution Wavelet Analysis, the intermediate values have least significance but the large number of intermediate values is generated. For example, the outputs of low pass filtering not required at each and every stage. An input image is passed through a series of filters to calculate the DWT coefficients. The procedure starts with passing this image through a half band digital low pass filter with impulse response h[n]. Wavelets are sets of general functions utilized as a part of the signal analysis and image compressions. For some decades, researchers required to utilize functions for the signal representations. Wavelets are generally known as the functions that are prepared as a superposition of some set of the general functions for the most utilized approximating information.

Wavelets are appropriate for approximating information with sharp discontinuities. Wavelets are one of the most appropriate functions of the entire waveform and also it decays as early. In the wavelet analysis, the transformation generally use the prototype function called the "Mother Wavelet".

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