Image Compression Based on Contourlet Transform

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Abstract---Image compression defines as reducing the amount of data required to represent digital image. Transform coding, on the other hand, first transforms the image from its spatial domain representation to a different type of representation using some well-known transform and then codes the transformed values (coefficients). There are mainly two Fourier based transformDCT and DWT are used for Image compression standards JPEG& JPEG2000 respectively.This two transform are not good enough for representing the geometric curve so need new techniques for image compression.This limitation is solving using the new technique called contourlet transform (CT). Which is based on Laplacian Pyramid and Directional Filter Banks (DFBs), can be capable of efficiently approximating natural images containing contours.

Keywords:- Image Compression, DCT, DWT, Contourlet Transform, Laplacian Pyramid(LP), Directional Filter Bank (DFB).

I. INTRODUCTION

Image compression defines as reducing the amount of data required to represent digital image. However, Image information contains a large of information, which brings a lot of difficulties for storage, processing and transmission. Thus image compression is very importance and necessity. There are two way to image compression (1) lossless compression and (2) lossy compression. Lossy image compression algorithms are applicable whenever the exact reconstruction of an image is not expected. These algorithms are usually based on transform methods. Due to the great use of digital information, image compression becomes imperative in different areas such as image storage, transmission and processing. At these areas the representation of the information needs to be efficient. The goal of image coding is to reduce the bit rate for signal transmission or storage while maintaining an acceptable image quality for different purposes.

Fourier-based transforms (e.g. DCT and DWT) are efficient in exploiting the low frequency nature of an image. However, a major disadvantage of these transforms is that the basis functions are very long. If a transform coefficient is quantized, the effect is visible throughout the image. This does not create much problem for the low frequency coefficients that are coded with higher precision [2]. However, the high frequency coefficients are coarsely quantized, and hence the reconstructed quality of the image at the edges will have poor quality. A sharp edge in an image is represented by many transform coefficients (that cancel each other outside the edge area) that must be preserved intact and in the same relationship to one another to achieve good fidelity of the reconstructed image.

Do and Vetterli proposed the contourlet transform as a directional multiresolution image representation that can efficiently capture and represent smooth object boundaries in natural images [2]. It realizes a multiscale and directional decomposition of an image using a combination of a modified laplacian pyramid (LP) and a Directional Filter Bank (DFB). CT allows for different number directions at each scale/resolution to nearly achieve critical sampling, so CT is capable of capturing contours and fine details in images and seems to be an appropriate candidate for image compression. A low bit-rate coding using the CT is proposed and experiment results show CT is capable of preserving more textures and details when compared to DCT & DWT.

II. CONTOURLET TRANSFORM

A. *Concept:*

Contourlet transform proposed by Do and Vetterli in 2002 not only has characteristics of multi-scale, time-frequency localization, but also a high directivity and anisotropy. Contourlet provide rich collection of directions and shapes, so it is more effective on capturing smooth contours and geometric structures.

(a) Wavelet (b) Contourlet

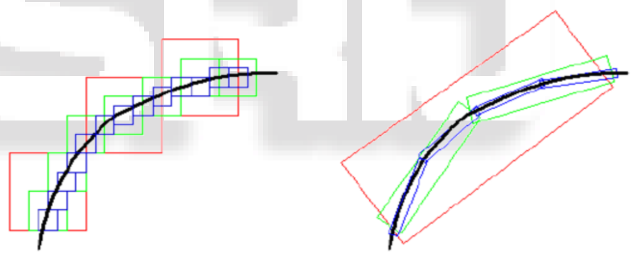


Fig. 1: Comparison of Contourlet versus wavelet

Consider the situation when a smooth contour is being painted, as shown in Fig. 1. Because 2-D wavelets are constructed from tensor products of 1-D wavelets, the "wavelet"-style painter is limited to using square-shaped brush strokes along the contour, using different sizes corresponding to the multiresolution structure of wavelets. As the resolution becomes finer, we can clearly see the limitation of the wavelet-style painter who needs to use many fine "dots" to capture the contour. The contourlet style painter, on the other hand, explores effectively the smoothness of the contour by making brush strokes with different elongated shapes and in a variety of directions following the contour.

Features of contourlet transform are described below [6].

- Multiresolution. The representation should allow imagesto be successively approximated, from coarse to fine resolutions.
- Localization. The basis elements in the representationshould be localized in both the spatial and the frequency domains.

— Critical sampling. For some applications (e.g., compression), the representation should form a basis, or a frame with small redundancy.
— Directionality. The representation should contain basis elements oriented at a variety of directions, much more than the few directions that are offered by separable wavelets.
— Anisotropy. To capture smooth contours in images, the representation should contain basis elements using a variety of elongated shapes with different aspect ratios.

B. Laplacian Pyramid:

One way to obtain a multiscale decomposition is to use the LP introduced by Burt and Adelson [7]. The LP decomposition at each level generates adownsampled low pass version of the original and the difference between the original and the prediction, resulting in a band pass image. Fig. 1(a) depicts this decomposition process, where H and Gare called (low pass) analysis and synthesis filters, respectively, and M is the sampling matrix. The process can be iterated on the coarse (downsampled low pass) signal. Note that in multidimensional filter banks, sampling is represented by sampling matrices; for example, down sampling x[n] by M yields, where M is an integer matrix [8].

The LP has the distinguishing feature that each pyramid level generates only a one band pass image (even for multidimensional cases), and this image does not have “scrambled” frequencies. This frequency scrambling happens in the wavelet filter bank when a high pass channel, after down sampling, is folded back into the low frequency band, and, thus, its spectrum is reflected. In the LP, this effect is avoided by down sampling the low pass channel only. The construction and reconstruction of LP is shown in Fig. 2

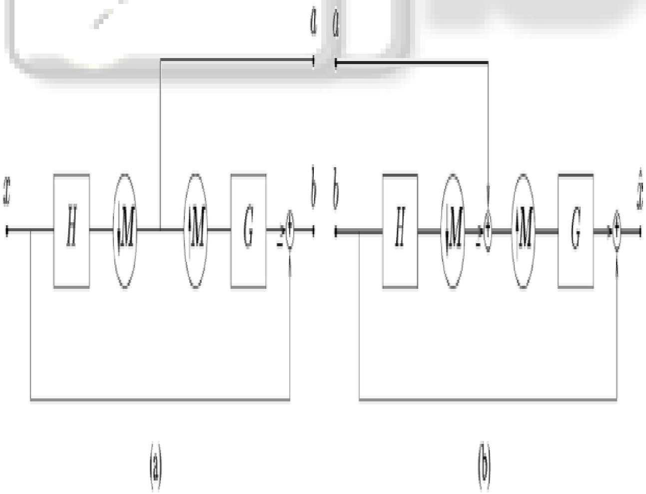
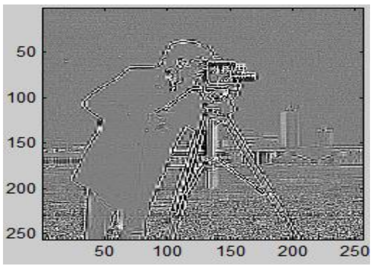
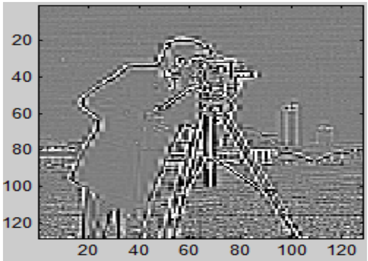


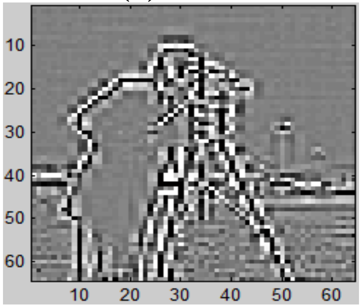
Fig. 2: LP. (a) One level of decomposition. (b) The reconstruction scheme for the LP



(A)Level 1



(B)Level 2



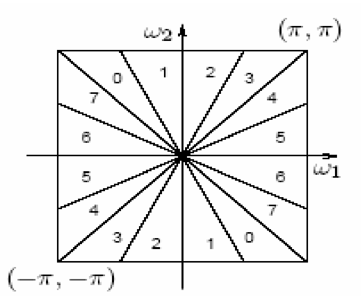
©Level 3

Fig. 3: Cameramanimage. Three levels of decomposition using laplacian pyramid.

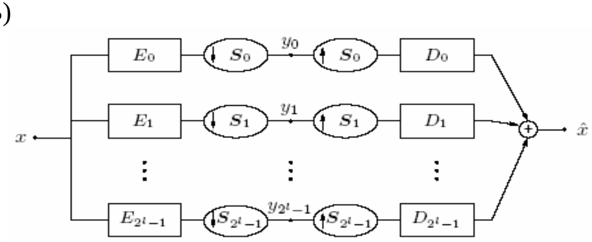
C. Directional Filter Banks:

Directional Filter Bank (DFB) was designed to capture the high frequency (representing directionality) of the processing image. Bamberger and Smith constructed a 2-D directional filter bank (DFB) that can be maximally decimated while achieving perfect reconstruction. As shown in Figure 2 (LiYu, Lin, 2007). Do and Vetterli proposed a new construction for the DFB to avoid modulating input image, which we can obtain the desired 2-D spectrum division as shown in Figure 4(a). The simplified DFB is intuitively constructed from two building blocks. The first is a two-D spectrum into two directions: horizontal and vertical. As shown in Figure 4(b). The second is a shearing operator, which used to reordering the image samples. By appropriate combination of shearing operators together with two-direction partition of quincunx filter banks at each node in a binary tree-structured filter bank, shown in Figure 4(c).The output results of DFB for decomposition level 2 are shown in Fig. 5

(A)



(B)



(C)

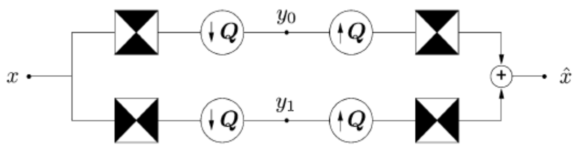


Fig. 4: (a) Frequency Partitioning (b) two-dimensional spectrum partition using quincunx filter banks with fan filters (c) The multichannel view of an llevel tree-structured DFB

Fig. 5: Contourlet Coefficients of a Cameraman Image

D. Compression Scheme:

The structure of contourlet based compression system is shown in Fig. 6. Firstly the image is applied to laplacian decomposition. Different levels of decomposition are performed on image. As directional decomposition is not suit to low-frequency sub bands, only the high frequency levels were decomposed by directional filters, for each sub bands, 8 directions were made. Then coding algorithm is used to code the data. After decompression process, the images are evaluated by performance parameters such as MSE & PSNR.

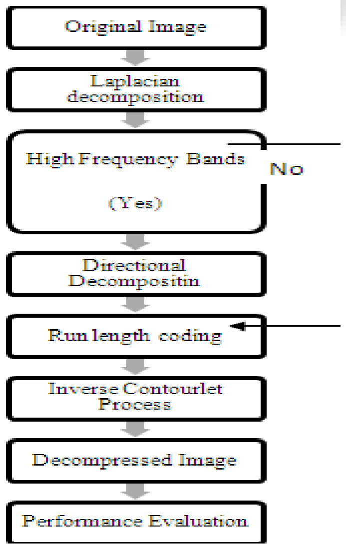


Fig. 6:

III. RESULTS& DISCUSSION

Contourlet based compression scheme is applied on cameraman image(256 x256). Reconstructed image from contourlet is compared with DCT & wavelet based compression scheme shown in Fig. 7.

– Comparing the Reconstructed Images

Fig. 7: (a) Original Image, (b) Local-enlarged of (a), (c) DCT Reconstructed Image, (d) Local-enlarged of (c), (e) Wavelet Reconstructed Image, (f) Local-enlarged of (e), (g) Contourlet Reconstructed Image, (h) Local-enlarged of (g)

Table 1: Performance parameters comparison of DCT, Wavelet and Contourlet based compression Technique for cameraman Image (256 x 256)

Method	Performance parameters		
	CR	MSE	PSNR
DCT	42.14	43.51	31.67
Wavelet (db4)	84.50	14.41	36.54
Contourlet	83.90	12.45	37.17

— Wavelet based Compression scheme achieve higher compression ratio (CR) compare to DCT & Contourlet based compression scheme.

— Contourlet based compression scheme shows the better MSE & PSNR results than DCT & Wavelet that shows the good quality of decompressed image.

— Better results of MSE & PSNR show that more directional detail are preserved in contourlet than DCT& Wavelet.

IV. CONCLUSION

Directional detail preserving limitation of DCT & wavelet can be solved using the new techniques called contourlet transform (CT). Which is based on laplacian pyramid and directional filter banks (DFBs), can be capable of efficiently preserved textures, edges and contours in an image.

The results of laplacian pyramid and Directional filter bank (DFB) are included in this paper. Contourlet transform shows the prefect reconstruction and Mean square error is zero.Contourlet based compression scheme shows the better MSE & PSNR results than DCT & Wavelet that shows the good quality of decompressed image.

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