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A Brief Review Of Researches On Performance Evaluation Of Image Compression Methods Using DCT And Enhanced DCT

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A B S T R A C T

Image compression using Transform-based coding is widely used in many application, such as JPEG, JPEG2000. Discrete Cosine Transform (DCT) is a popular image coding method used in image compression. A 2-D DCT of a square block is implemented separately as two 1-D transforms, along the vertical direction and the horizontal directions each. However, this is not a best fit method for image blocks containing directional edges. To overcome this, Directional DCT framework is applied, in which directional transform is done. In this method, the first transform may follow a direction other than the vertical or horizontal one, while the second transform is arranged to be a horizontal one. Directional transform is done to preserve the directional information of an image block. Studies have earlier showed that applying Directional DCT improved coding performance and rate-distortion coding performance. The researches earlier have evaluated the performance of the image compression techniques using quality parameters like – Coding Performance, Computational Time, Peak Signal to Noise Ratio, Mean Square Error. This paper gives a brief review of the researches done on the above subject.

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1. Introduction

Digital images from a big portion of multimedia data used by people. Data transmission and data storage are impacted by these huge volumes of images, especially due the size of each image. Hence, it is a good practice to compress the data, before it is transmitted or stored. One of the essential characteristics of image compression is that, after decompression, the decompressed image quality should be almost similar to the original image. An image compression method that achieves higher compression rate and less quality degradation is considered to be a good model. In the last few decades, many image compression methods have evolved. Most of these transforms apply the 2-D discrete cosine transform (DCT) on a square block of the image [1]. In practice, this conventional N x N DCT is always implemented separately through two N-point transforms, one along the vertical direction and another along the horizontal direction. Figure 1 shows the block diagram of the image compression and decompression system.

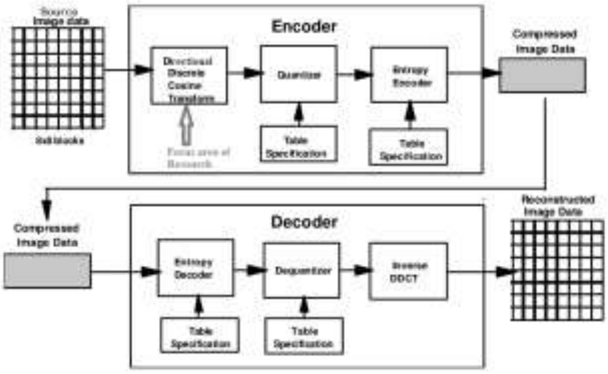

Figure 1 - Block diagram of directional DCT based Image Compression system.

However, in real world, images of natural objects and scenes have non-homogenous property, where the correlation of local contents in the image is often directional, i.e., the correlation along one direction is much stronger than those along other directions. Hence, it is important for efficient representation of directional information, for high performance image coding [2]. For image blocks in which vertical and/or horizontal edges are dominating, conventional DCT seems to be a good option. However, for image blocks with non-vertical and non-horizontal directional edges are dominating, conventional DCT may not be the best choice [1].

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Although it is not new to develop efficient schemes to better preserve directional information, designing transforms that can accommodate various directionality has never been easy.

Image coding needs to have the following properties for a good directional transform [2]:

- Efficient to represent various directional signals- To handle different contents in an image, the transform should be able to exploit the correlations along different directions, and thus the basis vectors should be directional and anisotropic.
- Easy to be implemented- An ordinary image may contain millions of pixels. To handle such a huge number of pixels, the transform should not be complicated.
- Non-redundant- The transformed coefficients should not be redundant. Although the transform itself is not necessary to be a critically-sampled one, it needs a very careful judgment to go over-complete or not.
- Able to take full advantage of exiting coding tools- Many coding tools are heavily tuned and already very mature. It is very difficult to start from zero to beat the current state-of-the-arts. For example, any new transform that can generate coefficients in a similar structure as those transforms used in the current coding schemes would be highly appreciated. However, since such new outcome is very limited, existing models should be leveraged.

For compression of images which are directional in nature, Directional DCT framework is applied, in which directional transform is done. In this method, the first transform may follow a direction other than the vertical or horizontal one, while the second transform is arranged to be a horizontal one. Directional transform is done to preserve the directional information of an image block. 8 directions are considered for directional transform, as given in figure 2For compression of images which are directional in nature, Directional DCT framework is applied, in which directional transform is done. In this method, the first transform may follow a direction other than the vertical or horizontal one, while the second transform is arranged to be a horizontal one. Directional transform is done to preserve the directional information of an image block. 8 directions are considered for directional transform, as given in figure 2.

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0. Vertical
1. Horizontal
2. Diagonal Down-Left
3. Diagonal Down-Right
4. Vertical Right
5. Horizontal Down
6. Vertical Left
7. Horizontal Up

Fig.2 – 8 directional modes

Pictorial representation of the 8 directional modes for transform is given in figure 3.

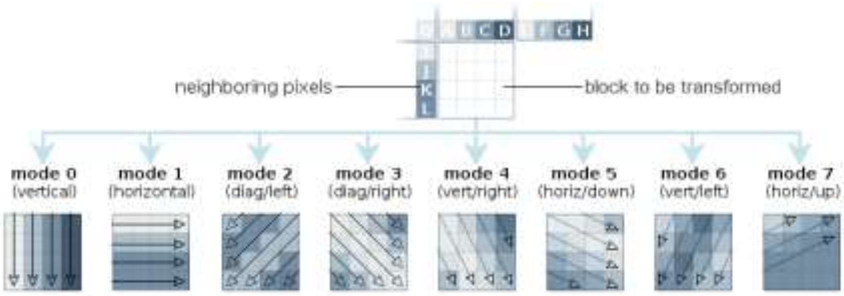

Figure 3 - Pictorial representation of the 8 directional modes for transform [3]

1-D direct cosine transform applied on directional image block is given figure 4 below:

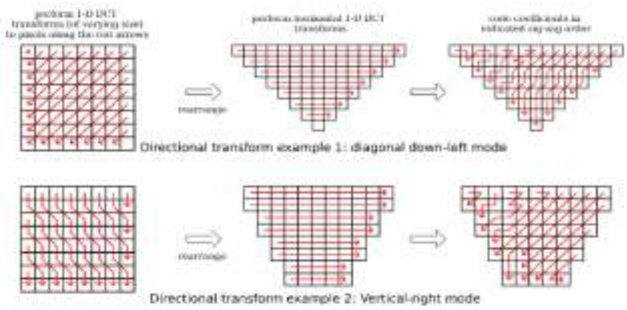

Figure 4- Sample pictorial representation of directional transforms for 2 of the directional modes [3]

Several directional transforms have been proposed and applied in image coding. These can be divided into several categories. In the first category, pixels in an image block are re-organized according to a selected direction, and the conventional transforms are then applied.

In the second category, lifting-based approaches are used to change the conventional transforms to be directional.

In the third category, the directional transform is constructed by a directional prediction and a corresponding data-dependent transform thereafter.

This paper uses secondary data in the form of papers published in different internal journals. These research papers are analyzed and reviewed.

2. Brief Review of Previous Researches

Bing Zeng and Jingjing Fu [1] developed a new block-based DCT framework in which the first transform followed a direction other than the vertical or horizontal one, while the second transform was arranged to be a horizontal one. Compared to the conventional DCT, the resulting directional DCT framework was able to provide a better coding performance for image blocks that contained directional edges. By choosing the best from all directional DCT's for each image block, it was demonstrated that the rate-distortion coding performance had improved remarkably.

Chuo-Ling Chang et,al. [4] has proposed the direction-adaptive partitioned block transform (DA-PBT), which exploited the directional features in color images to improve coding performance. In this method, depending on the directionality in an image block, the transform either selects one of the eight directional modes or falls back to the non-directional mode equivalent to the conventional 2-D DCT. The selection of a directional mode determines the transform direction that provides directional basis functions, which result in efficient entropy coding and optimized quantization matrix. Rate-distortion optimized framework along with variable block size transforms is used in this experiment. Experimental results showed that the proposed DA-PBT outperformed the 2-D DCT by more than 2 dB for test images with directional features. The DA-PBT also consistently outperformed the regular directional DCT.

S. Zhu et,al. [5] attempted to determine the Rate Distortion performance upper bound for block-based transform coding schemes applied on 2D directional sources. Karhunen-Loeve transform (KLT) was applied in this model. It was shown that a non-separable KLT could be determined directly from the given 2D directional source model to yield the R-D performance upper bound. It was also shown that there existed a significant gap between this upper bound and the R-D performance and that achieved by using the traditional 2D DCT.

M. Hangarge et,al.[6] have developed directional discrete cosine transform (D-DCT) based word level handwritten script identification. They investigated two different methods to capture directional edge information, one by performing 1D-DCT along left and right diagonals of an image, and another by decomposing 2D-DCT coefficients in left and right diagonals. The mean and standard deviations of left and right diagonals of DCT coefficients are computed and are used for the classification of words using linear discriminant analysis (LDA) and K-nearest neighbour (K-NN). This method was validated over 9000 words belonging to six different scripts. The classification of words is performed at bi-scripts, tri-scripts and multi-scripts scenarios and accomplished the identification accuracies respectively as 96.95%, 96.42% and 85.77% in average. It focused on the character recognition, rather than on compression.

Bo Chen et,al. [7] proposed a fast directional discrete cosine transform (FDDCT) for efficient representation of anisotropic edges in images. The transform is performed on the predefined direction lines. Comparing to the directional discrete cosine transform (DDCT), no interpolation is needed in FDDCT. In DDCT, interpolation on the fractional pixels is the main reason that causes large amounts of computation. Interpolation could be avoided by using integer pixels to approximate the edges. In this paper, five fixed direction modes are used, instead of interpolation. It was also found that five modes were enough to approximate well most directions of edges in images. Thus, the amount of computation decreased by 80%. Simulation results indicated that the peak signal-to-noise ratios of images compressed using FDDCT are >1 dB higher than those using Directional DCT.

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Gowri Sankar and Veera Reddy [8] proposed a hybrid model of image compression based on uniform thresholding and fixed point binary scaling. The objective was to reduce the computational complexity for compressing satellite Images. Variable bit rate is obtained using fixed point binary scaling and adjusting slope factor. Some images from LANDSAT 8 are compressed and the image quality metrics- bits per pixel (bpp), peak signal to noise ratio(PSNR) and computational time are measured for the proposed method and the discrete cosine transform (DCT). The proposed method from medium to high bitrates performed better than the discrete cosine transform (DCT) based method in terms of PSNR and computational time.

Chuo-Ling Chang and Bernd Girod [9] proposed a direction-adaptive DWT (DA-DWT) that locally adapts the filtering directions to image content based on directional lifting. With the adaptive transform, energy compaction is improved for sharp image features. A mathematical analysis based on an anisotropic statistical image model is presented to quantify the theoretical gain achieved by adapting the filtering directions. Experimental results report a gain of up to 2.5 dB in PSNR over the conventional DWT for typical test images. Subjectively, the reconstruction from the DA-DWT better represents the structure in the image and is visually more pleasing.

3. Conclusion

This paper briefly reviewed the different researches done on image compression methods and their performance evaluation. It is found that many researches were done to leverage the directional information of an image in the process of image compression. Some used direction-adaptive partitioned block transform (DA-PBT) [4], some used non-separable Karhunen-Loeve transform (KLT) [5], some researchers worked on directional-adaptive wavelet transform (DA-DWT) [9] and some on directional discrete cosine transform (DDCT) [1]. Few researchers have used fast directional discrete cosine transform (FDDCT) [7] also. The image compression done using different models were evaluated by the researchers by reconstructing the image and comparing the input and output images against the image quality metrics such as Peak Signal to Noise Ratio (PSNR), Mean Square Error (MSE), Bitrate, Computational Time, Compression Ratio, Rate-Distortion function. However, not many researchers evaluated their output based on the quality metrics like SSIM Index, Image

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Quality Index. So, more research can be done by evaluating the performance of the image compression methods using SSIM Index and Image Quality Index.

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