Improvement of Hybrid Image Compression Technique

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Abstract - *Image compression is an application of data compression that encodes the original image with few bits. The objective of image compression is to reduce the redundancy of the image and to store or transmit data in an efficient form. The image compression may be lossy or lossless. Lossless compression is preferred for archival purposes and often for medical imaging, technical drawings, clip art, or comics. Lossy compression methods, especially when used at low bit rates, introduce compression artifacts. Lossy methods are especially suitable for natural images such as photographs in applications where minor (sometimes imperceptible) loss of fidelity is acceptable to achieve a substantial reduction in bit rate. The lossy compression that producible differences may be called visually lossless. Digital imaging generates a large amount of data which needs to be compressed, without loss of relevant information, to economize storage space and allow speedy data transfer. Many lossless and lossy image compression schemes exist for compression of images in space domain and transform domain. Employing more than one traditional image compression algorithms results in hybrid image compression techniques. Novel hybrid image compression schemes are developed to compress the images effectually maintaining the quality*.

Key Words: Image, Techniques, lossless, DCT, CALIC,CALIC-SPS,BDCT.

1. INTRODUCTION

1.1 Introduction to Image Compression

In today's modern era, multimedia technology has tremendous impact on human lives. Image is one of the most important media contributing to multimedia. Information transmission is the key means to acquire and give the knowledge or data related to a particular event. For example: video conferences, medical data transfer, business data transfer and so on, require much more image data to be transmitted and stored on-line. Due to the internet, the huge information transmissions take place.

The processed data required much more storage, computer processor speed and much more bandwidth for transmission. While the advancement of the computer storage technology continues at the rapid rate. The means for reducing the storage requirement of image is still needed in most of the situations. And hence it is highly desirable that the image be processed, so that efficient storage, representation and transmission of the image can be worked out. The processes involve one of the important tasks - Image Compression. Methods for digital image compression have been the subject of research over the past three decades. Recently, the need for efficient image compression systems can be seen.

The performance of any image compression scheme depends upon its ability to capture characteristic features from the image, such as sharp edges and fine textures, while reducing the number of parameters used for its modeling . Image compression is one of the most important and successful applications of the wavelet transform. The compression techniques can be classified as: lossless methods and lossy methods. The first class is composed of those methods which reconstruct an im-age identical to the original; the second comprises compression methods which lose some image details after their application: the reconstruction is an approximation of the original image . Well known JPEG based on DCT is lossy compression techniques with relatively high compression ratio which is done by exploiting human visual perception. For the lossy compression, some irrelevant data will be thrown away during the compression. The recovered image is only an approximated version of the original image.

This implies that the reconstructed image is always an approximation of the original image. The exact copy of the original image can be completely recovered. Lossless image compression algorithms are divided into *sequential* algoritms like (Fast Efficient and Lossless Image Compression System) FELICS, (Low Complexity Lossless Compression for Images) LOCO-I, (Context Adaptive Lossless Image Com-pression) CALIC , some new context-based algorithms and transformbased ones like lossless SPIHT (set partitioning in hierarchical trees).

1.2 Problem Statement

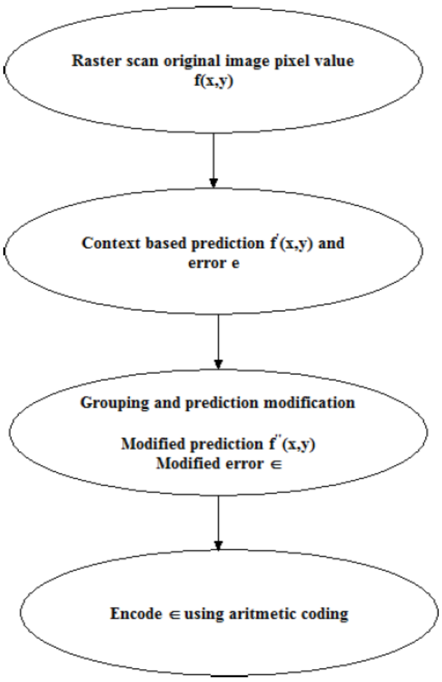
The problem taken to develop efficient hybrid image compression schemes *that yield higher quality in terms of subjective and objective evaluations at lower bit-rates.*

2 BASIC IMAGE COMPRESSION SCHEMES

2.1 Context Adaptive Lossless Image Coding (CALIC) Algorithm

The CALIC scheme came into being in response to a call for proposal for a new lossless image compression scheme in 1994. It uses both context and prediction of the pixel values. In an image, a given pixel generally has a value close to one of its neighbours. Which neighbour has the closest value depends on the local structure of the image.

Depending on whether there is a horizontal or vertical edge in the neighbourhood of thepixel being encoded, the pixel above, or the pixel to the left, or some weighted average of neighbouring pixels may give the best prediction. How close the prediction is to the pixel being encoded depends on the surrounding texture. In a region of the image with a great deal of variability, the prediction is likely to be farther from the pixel being encoded thanin the regions with less variability. In order to take into account all these factors, the algorithm has to make a determination of the environment of the pixel to be encoded.



2.2 Discrete Cosine Transform based Compression

Disintegrating the images into segments is the fundamental operating principle of DCT. A better signal approximation with fewer transform coefficients are provided by DCT which are real valued unlike those obtained in a DiscreteFourier Transform.

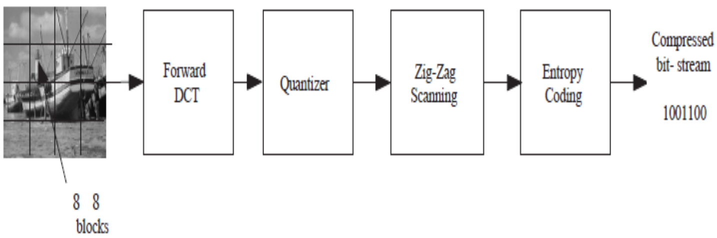
In several practical image compression systems the invertible linear transform called 2-dimensional DCT is extensively used because of its compression performance and computational efficiency. Data (image pixels) is converted into sets of frequencies, by DCT. The frequency sets are arranged in ascending order of frequency and descending order of significance as far as image quality is concerned. On the basis of tolerable resolution loss, the least meaningful frequencies can be discarded.

2.2 Global DCT versus Block DCT (BDCT)

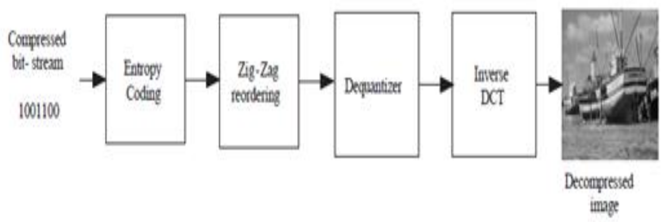
For the purpose of image compression, DCT can be applied to the complete image (global DCT) or to an $n \times n$ block of image(BDCT). Applying DCT to entire image produces better compression but involves extremely large number of arithmetic operations thus adding to its computational complexity. Therefore, the process of compression slows down. On the other hand, applying DCT to small data units is faster but reduces the compression ratio. Moreover, in the continuous tone images, the correlations between pixels are in short range. Statistical analysis of natural images has revealed that there is little correlation between pixels more than 8 positions apart and, in fact, most of the correlations are among pixels that are within 4 positions away. The 8×8 block size is an excellent choice from both the bit-rate and the correlation-exploitation points of consideration

2.3 Block DCT based Compression

The compression and decompression process based on BDCT. The image is divided into non-overlapping blocks of size 8×8 or 16×16. In standard JPEG encoding, it is divided into 8×8 blocks in the raster scan order form left to right and top to bottom.



From the lowest (upper left corner) to the highest (lower right corner) frequencies, 64 DCT coefficients are computed for each block [2]. All DCT coefficients are encoded by using a constant number of bits. But, the importance (the ratio between an upper left corner coefficient and the one in the right bottom corner) is not the same for all the coefficients .

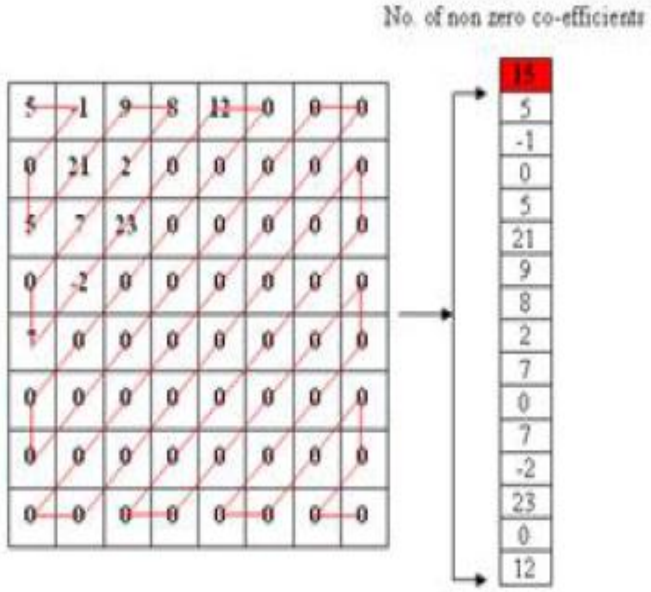


3. ENHANCEMENT OF HYBRID IMAGE COMPRESSION USING DCT AND FRACTALS

3.1 The Compression Process

A novel image compression scheme is developed here to compress the images combining DCT and the idea of fractal image compression. The proposed scheme divides the input image $f(x, y)$ into sub-images $g(x, y)$. Each sub-image $g(x, y)$ is further tiled into blocks of size 8×8. The 8×8 block of data is transformed using two dimensional DCT and the transformed values are quantized using standard JPEG quantization table. The entire quantized coefficients of the 8 × 8 block are rearranged in a zig-zag Manner.

Most of the high frequency coefficients (lower right corner) become zeros after quantization. A zig-zag scan of the matrix yielding long strings of zeros is used to exploit the number of zeros. The current coder acts as filter and passes only the string of non-zero coefficients. A list of non-zero coefficients of the blocks in the order of their count will be obtained at the end of this process. It is repeated for all the blocks of sub-image, $g(x, y)$.

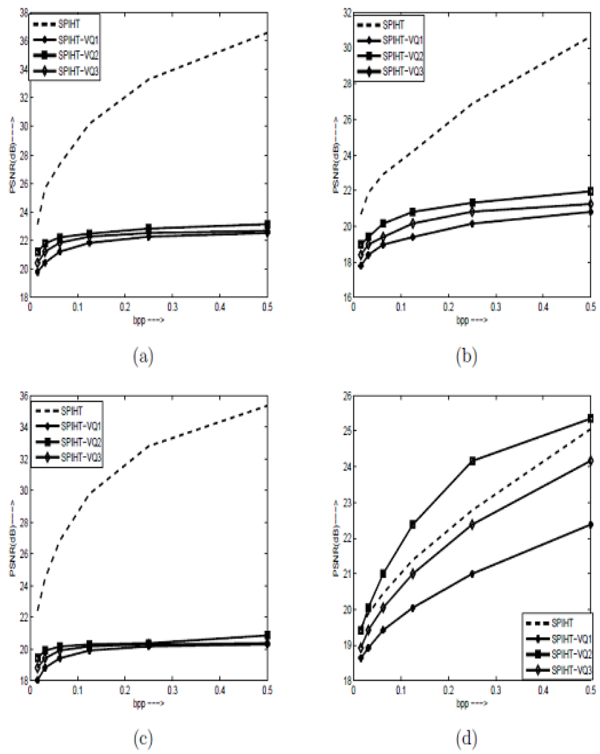


4. HYBRID IMAGE COMPRESSION BASED ON CALIC AND SPATIAL PREDICTION STRUCTURES

Structure components such as edges, contours, and textures are found in natural images. These components repeat themselves at various locations and scales. Therefore, an image prediction scheme that exploits this type of image correlation in spatial domain can be developed.
This type of image correlation has been exploited in spatial prediction structures. The spatial structure prediction algorithm breaks the neighborhood constraint, attempting to find an optimal prediction of structure components from the previously encoded image regions. It borrows the idea of motion prediction from video coding, which predicts a block in the current frame using its previous encoded frames.

To improve the compression, the image is classified into two types of regions: namely the *structure regions* and the *non-structure regions*. Non-structure regions are smooth image areas that can be efficiently represented [149] with the spatial transforms, such as KLT (Karhunen Loeve transform), DCT and DWT. The structure regions, on the other hand, consist of high-frequency components and curvilinear features in images, such as edges, contours, and texture regions, which cannot be efficiently represented by the linear spatial transforms.

The structured regions are hard to compress and consume a majority of the total encoding bits. The structure regions are encoded with spatial prediction structures while non structure regions can be efficiently encoded with conventional image compression method, CALIC . There is no codebook requirement in the compression scheme, since the best matches of structure components are simply searched within encoded image regions.



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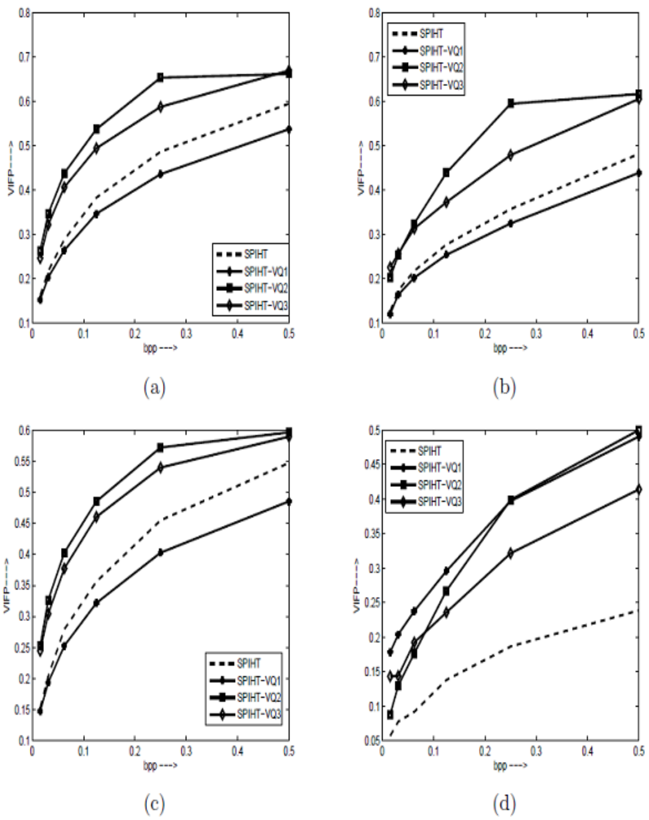
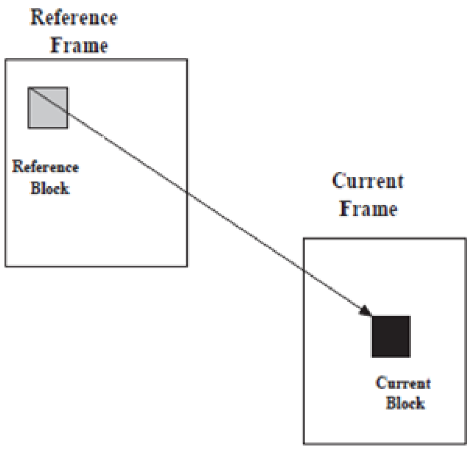
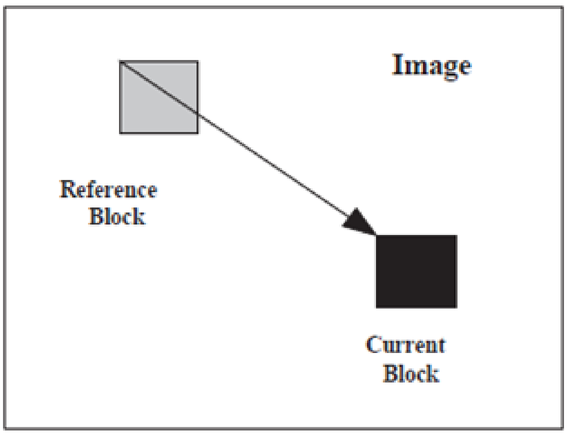




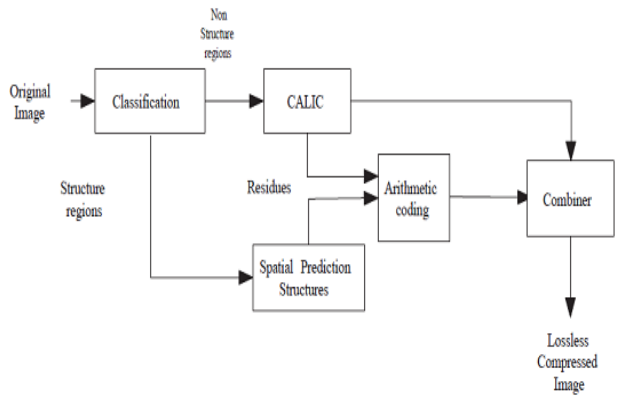


4.1 Spatial Prediction Structures

The idea of spatial prediction structure comes from motion prediction used in video coding [6]. In motion prediction, an area in the reference frame is searched to find the best match of the current block based on some distortion metric. The chosen reference block becomes the predictor of the current block.

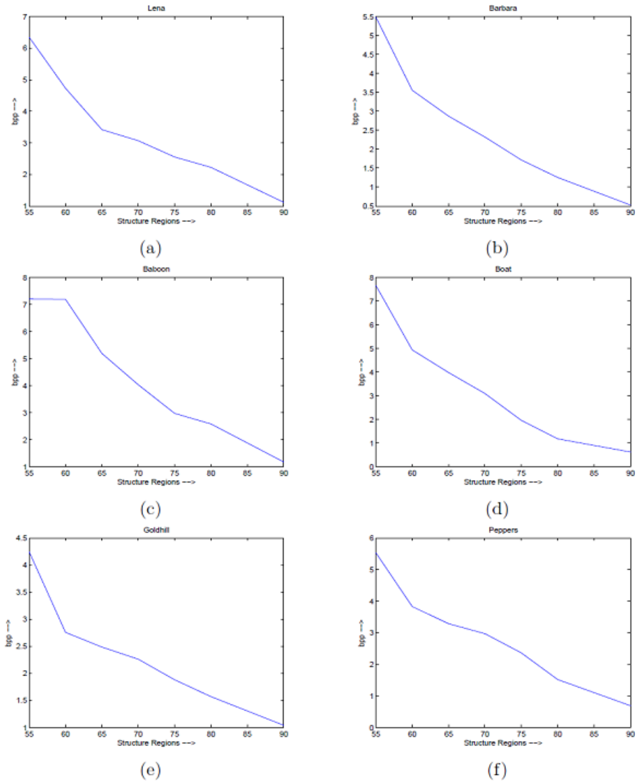
The prediction residual and the motion vector are then encoded and sent to the decoder. In spatial prediction structures, regions within the previously encoded image regions are searched to find the prediction of an image block. The reference block that results in the minimum block difference in terms of SAD is selected as the optimal prediction. shows the block diagram of the hybrid image compression scheme based on spatial prediction of structural components.

First, we classify the input data into two categories: structural regions and non-structural regions, where structure regions consist of high frequency regions, and non structure regions consists of smooth areas. The upper output of CALIC to the combiner represents the bit stream corresponding to non structure regions. The process of classification, employed here, is described in detail in the following section.



Coding Performance of CALIC-SPS

The coding scheme is evaluated for compression performance for both the grayscale and color images. Bit-rate is used as metric to specify the compression performance. The test images used for simulation are of size 512×512, with tonal resolution of 8 bits per pixel. The bit-rate has been calculated for all test images when only CALIC is applied and when the CALIC is applied in combination with spatial prediction structures, using both direct prediction mode and intraprediction modes. The compression performance of spatial prediction structures prediction with CALIC is calculated for various test images using both direct prediction mode and intra-prediction modes.



5. CONCLUSION

The analysis, presented in the previous section, leads us to draw the following conclusion.

• The proposed scheme, SPIHT-VQ2 performs better than the other schemes at 0.25 bpp . A bit-rate of 0.25 bpp (CR = 32) is good enough to preserve the image details with quite less distortion. A bit-rate of 0.125 bpp (CR = 64) may also be accepted in some applications where we can tolerate little more distortion. The proposed scheme DCT-F gives promising results, maintaining the quality in terms of objective metrics with slightly extra compression.

• The modified point-wise SA-DCT approach for deblocking provides the improvement in visual appearance of the image.

• Our proposed scheme, CALIC-SPS provides better compression than the existing standard method CALIC for lossless compression by yielding lower bit-rate. Finally, it may be concluded that we may select CALIC-SPS algorithm for lossless compression whereas SPIHT-VQ2 will be a better candidate for lossy compression systems.

Future Work: The research work in this thesis can further be extended in the following directions:

- Adaptive HVS and modified SPIHT can be used with VQ to improve the performance of SPIHT-VQ by a large margin. Post processing techniques may be used to further enhance the subjective quality of images.
- DCT-F algorithm can be extended for color image/video coding by exploiting correlations among different color planes.
- Adaptive threshold may be employed to improve the coding efficiency of CALIC-SPS.

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