High Quality Image Compression –Wavelets & Canny Edge Detector

ABSTRACT

Image compression is a fast paced and dynamically changing field with many different types of compression methods. Images contain large amount of data hidden in them, which is highly correlated. Image compression plays a vital role in several important and diverse applications, including televideo conferencing, remote sensing, medical imaging magnetic resonance imaging. These require fast transmission and large space to store data. These requirements are not fulfilled with old techniques of compression like Fourier Transform, Hadamard and Cosine Transform etc. In this paper presents a new approach of edge preserving and edge based segmentation for compression of images using Modified Fast Haar wavelet transform (MFHW) and Bit Plane Encoder to elevate the compression ratio with high picture quality. The edges of an image are preserved to increase the PSNR, and then the detected edges are used to segment the foreground and background images. The Foreground of the image is given more importance than the background images. A wavelet transform is used to extract the redundant information at low frequency and a matching Bit Plane encoder is used to code the segments of the image at different quality levels. The Proposed method highly preserves quality of the foreground image. Normal compression algorithms will not preserve the high frequency details such as edges, corners etc., in this method edges are preserved and used for segmenting the layers of the original image.

Keywords: Fourier Transform, Haar Wavelet, Bit Plan Encoder, Image Compression.

I. INTRODUCTION

Computer graphics applications, particularly those generating digital photographs and other complex color images, can generate very large file sizes. Issues of storage space, and the need to rapidly transmit image data across networks and over the internet, has led to the development of a range of image compression techniques in order to reduce the physical size of the files without degrading the quality of the image to an unacceptable level. Image compression, intends to yield a compact representation of an image. The reduction in file size allows more images to be stored in a certain amount of disk or memory space. It also reduces the time necessary for images to be sent through the channel in image compression, there is a relaxation of usage of more number of bits to represent regions of interests such as edges of an image, which indirectly implies the details of image. Higher compression ratios can only be achieved at the expense of higher distortion that degrades the quality of the image. This trade-off between the high compression and the quality of an image should be handled. To meet the challenges of achieving even high compression ratio along with the better image quality the better method of processing the image should be made out. In the transform-based compression techniques, the cost function is the energy or frequency contents of the image, which is concentrated in the lower values. Compression is achieved through the elimination of the higher energy or frequency values, which are less concentrated and therefore deemed less important.

In 1992, JPEG established the first international standard for still image compression where the encoders and decoders are DCT-based. The JPEG standard specifies three modes namely sequential, progressive, and hierarchical for lossy encoding, and one mode of lossless encoding. The performance of the coders for JPEG usually degrades at low bit-rates mainly because of the underlying block-based Discrete Cosine Transform (DCT) [4]. The baseline JPEG coder [5] is the sequential encoding in its simplest form. Fig. 1 and 2 show the key processing steps in such an encoder and decoder respectively for grayscale images. Color image compression can be approximately regarded as compression of multiple grayscale images, which are either compressed entirely one at a time, or are compressed by alternately interleaving 8x8 sample blocks from each in turn.

The DCT-based encoder can be thought of as essentially compression of a stream of 8x8 blocks of image samples. Each 8x8 block makes its way through each processing step, and yields output in compressed form into the data stream. Because adjacent image pixels are highly correlated, the Forward DCT (FDCT) processing step lays...
the basis for gaining data compression by concentrating most of the signal in the lower spatial frequencies. For a typical 8x8 sample block from a typical source image, most of the spatial frequencies have zero or near-zero amplitude and need not to be encoded. Generally, the DCT introduces no loss to the source image samples; it merely transforms them to a domain in which they can be more efficiently encoded.

After output from the Forward DCT (FDCT), each of the 64 DCT coefficients is uniformly quantized in conjunction with a carefully designed 64-element Quantization Table (QT). At the decoder, the quantized values are multiplied by the corresponding QT elements to pick up the original unquantized values. After quantization, all the quantized coefficients are ordered into zig-zag sequence. This ordering helps to facilitate entropy encoding by placing low frequency non-zero coefficients before high-frequency coefficients. The DC coefficient, which contains a significant fraction of the total image energy, is differentially encoded.

Entropy Coding (EC) achieves additional compression loss lessly through encoding the quantized DCT coefficients more compactly based on their statistical characteristics. The JPEG proposal specifies both Huffman coding and arithmetic coding.

More recently, the wavelet transform has emerged as a cutting edge technology, within the field of image analysis. Wavelets are a mathematical tool for hierarchically decomposing functions. Though rooted in approximation theory, signal processing, and physics, wavelets have also recently been applied to many problems in Computer Graphics including image editing and compression, automatic level-of-detail control for editing and rendering curves and surfaces, surface reconstruction from contours and fast methods for solving simulation problems in 3D modeling, global illumination, and animation [6].

Wavelet-based coding [7] provides substantial improvements in picture quality at higher compression ratios. Over the past few years, a variety of powerful and sophisticated wavelet-based schemes for image compression have been developed and implemented. Because of the many advantages of wavelet based image compression as listed below, the top contenders in the JPEG-2000 standard [8] are all wavelet-based compression algorithms.

- Wavelet coding schemes at higher compression avoid blocking artifacts.
- They are better matched to the HVS (Human Visual System) characteristics.
- Compression with wavelets is scalable as the transform process can be applied to an image as many times as wanted and hence very high compression ratios can be achieved.
- Wavelet based compression allow parametric gain control for image softening and sharpening.
- Wavelet-based coding is more robust under transmission and decoding errors, and also facilitates progressive transmission of images.
- Wavelet compression is very efficient at low bit rates.
- Wavelets provide an efficient decomposition of signals prior to compression.

A. Classification of Compression Technique

- There are two ways that we can consider for classifying compression techniques-lossless vs. lossy compression and predictive vs. transform coding.

- In lossless compression schemes, the reconstructed image, after compression, is numerically identical to the original image. However lossy compression can only achieve a modest amount of compression. An image reconstructed following lossy compression contains degradation relative to the original. Often this is because the compression scheme completely discards redundant information. However, lossy schemes are capable of achieving much higher compression. Under normal viewing conditions, but the quality of image is lost.

- In predictive coding, information already sent or available is used to predict future values, and the difference is coded. Since this is done in the image or spatial domain, it is relatively simple to implement and is readily adapted to local image characteristics. Differential Pulse Code Modulation (DPCM) is one particular example of predictive coding. 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). This method provides greater data compression compared to predictive methods, although at the expense of greater computation.

II. EXISTING SYSTEM
Image compression is a fast paced and dynamically changing field with many different types of compression methods. Images contain large amount of data hidden in them, which is highly correlated. Image compression plays a vital role in several important and diverse applications, including televideo conferencing, remote sensing, medical imaging, magnetic resonance imaging. These require fast transmission and large space to store data. These requirements are not fulfilled with old techniques of compression like Fourier Transform, Hadamard and Cosine Transform etc.

The problem in lossless compression method is that, the compression ratio is very less; whereas in the lossy compression the compression ratio is very high but the quality of the image is lost.

III. PROBLEM SPECIFICATION

HAAR Wavelet Transform

- Wavelets are mathematical tools for hierarchically decomposing functions.
- Wavelet Transform has been proved to be a very useful tool for image processing in recent years.
- It allows a function which may be described in terms of a coarse overall shape, plus details that range from broad to narrow.
- The most distinctive feature of Haar Transform lies in the fact that it lends itself easily to simple manual calculations.
- The wavelet transform is often used for signal and/or image smoothing keeping in view of its “energy compaction” properties, i.e. large values tend to become larger and small values smaller, when the wavelet transform is applied.
- The Haar Transform is memory efficient, exactly reversible without the edge effects, it is fast and simple. As such the Haar Transform technique is widely used these days for wavelet analysis.
- The Haar Transform (HT) is one of the simplest and basic transformations from the space domain to a local frequency domain.
- A HT decomposes each signal into two components, one is called average (approximation) or trend and the other is known as difference (detail) or fluctuation.
- A precise formula for the values of first average sub-signal a=(a1,a2,a3,......an/2), at one level for signal of length N i.e f=(f1,f2,f3......fn) is

\[ a_n = \frac{f_{2n-1}+f_{2n}}{\sqrt{2}}, n = 1,2,3 \ldots \frac{N}{2} \]  

The first detail sub-signal d=(d1,d2,d3,......dn/2) at the same level is given as

\[ d_n = \frac{f_{2n-1}-f_{2n}}{\sqrt{2}}, n = 1,2,3 \ldots \frac{N}{2} \]

- The haar wavelet transform produces four areas A, H, V and D respectively.
- A (approximation area) includes information about the global properties of analysed image. Removal of spectral coefficients from this area leads to the biggest distortion in original image.
- H (horizontal area) includes information about the vertical lines hidden in image. Removal of spectral coefficients from this area excludes horizontal details from original image.
- V (vertical area) contains information about the horizontal lines hidden in image. Removal of spectral coefficients from this area eliminates vertical details from original image.
- D (diagonal area) embraces information about the diagonal details hidden in image. Removal of spectral coefficients from this area leads to minimum distortions in original image.

Modified Fast Haar Wavelet Transform

- Fast Haar Transform (FHT) involves addition, subtraction and division by 2, due to which it becomes faster and reduces the calculation work in comparison to HT.
- For the decomposition of an image, we first apply 1D FHT to each row of pixel values of an input image matrix.
- These transformed rows are themselves an image and we apply the 1D FHT to each column. The resulting values are all detail coefficients except for a single overall average coefficient.
- In MFHWT, first average sub-signal a=(a1,a2,a3,......an/2), at one level for signal of length N i.e f=(f1,f2,f3......fn) is

\[ a_n = \frac{f_{2n-3}+f_{2n-2}+f_{2n-1}+f_{2n}}{4}, m = 1,2,3 \ldots \frac{N}{2} \]  

The first detail sub-signal d=(d1,d2,d3,……dn/2) at the same level is given as

\[ d_n = \left(\frac{f_{2n-3}+f_{2n-2}}{4}\right)-\left(\frac{f_{2n-1}+f_{2n}}{4}\right), m = \frac{N}{2},\ldots, N \]  

Here four nodes are considered at a time instead of two nodes as in HT and FHT. The author has considered the values of N/2 detail coefficients zero in each step than to find the N/2 detail coefficients by FHT.

Edge Detection

Edge detection refers to the process of identifying and locating sharp discontinuities in an image. The discontinuities are abrupt changes in pixel intensity which characterize boundaries of objects in a scene. Classical methods of edge detection involve convolving the image with an operator (a 2-D filter), which is constructed to be sensitive to large gradients in the image while returning values of zero in uniform regions.
There are an extremely large number of edge detection operators available, each designed to be sensitive to certain types of edges. Variables involved in the selection of an edge detection operator include Edge orientation, Noise environment and Edge structure. The geometry of the operator determines a characteristic direction in which it is most sensitive to edges.

In our proposal canny edge detector is used which has high localization and error free characteristics. The Canny edge detection algorithm is known to many as the optimal edge detector.

**Step1**: Read the image. Filter out the noise in the image and smoothening is done using Gaussian filter.

**Step2**: Find the gradient of the image in the x and y direction and respectively and hence calculate the magnitude.

**Step3**: Determine the gradient of the image.

**Step4**: Rotate the edge direction to a direction that can be traced in an image.

**Step5**: Suppress the non maximum value, which is not considered to be an edge.

**Step6**: Using two threshold and to eliminate the unwanted edge points. Any pixel between thresholds is assumed to be an edge pixel and other pixel points are set to zero.

Operators can be optimized to look for horizontal, vertical, or diagonal edges. Edge detection is difficult in noisy images, since both the noise and the edges contain high frequency content. Attempts to reduce the noise result in blurred and distorted edges.

Operators used on noisy images are typically larger in scope, so they can average enough data to discount localized noisy pixels.

**Page Layout**

The segmentation of foreground and background image is computed after detecting the edges using Canny Edge Detector. The scan line algorithm is applied to fill in the space surrounded by the edges. The horizontal and vertical scanning is made individually and the result is combined to get the foreground image. In horizontal scan line process, the scanning starts from left to right to find non-zero value in the matrix E. For scanning a line or row i, the column j varies from 1 towards n, and test for non-zero value in Eij, when non zero value of Eij is found, set j as the starting column L, now the scan proceeds from right to left to find the right most edge pixel, the column starts from n towards 1 to find a non-zero element at row i, when the non-zero Eij is found , set j as the ending column W. Now fill the line from EiL to EiW.

After iterating the process for all the rows in the image, the horizontally filled image would be ready, in the same way vertical scan line process starts from top to bottom that is keeping the column fixed and change the row from 1 to m. After finishing vertical scan line procedure, the two images are combined by logical AND operation. The resultant image is a binary image in which the foreground is denoted by 1 and the background is denoted by 0. The segmented image is used in the proposed algorithm to resolve whether to compress a pixel using high quality compression or not.

**Bit Plane Encoder**

After applying the MFHWT, the wavelet transformed coefficients are either rounded to the nearest integer (when the floating-point transform is used), or scaled using the weighting factors (when the integer transform is used). The Round-off operation makes the compression a lossy compression. On the other hand, the scaled operation after the integer wavelet transform makes the compression a lossless compression. The rounded or scaled coefficients are first grouped into blocks. Several consecutive blocks are grouped into a segment. Segments are then encoded by the bit-plane encoder. The BPE successively encodes bit planes of coefficient magnitudes in a segment, inserting AC coefficient sign values at appropriate points in the encoded data stream. Coding of a bit plane is performed in stages number 0-4. A coded bit plane first consists of all the stage 0 bits (if any) in the segment, then all off the coded stage 1 bits in the segment, and so on, finishing with all of the encoded stage 4 bits in the segment. The output bit stream is then formed and sent. The formation of a coding block is shown in Figure 3 [8]. The bit plane encoder is mainly used in satellite images for achieving high quality of pictures. This when combined with adaptive wavelet Transform it provides progressive compression ratio with picture quality, comparatively with other coders. The coding time is reduced using Bit Plane Encoder.

**IV.PROPOSED IMAGE COMPRESSION METHOD**

In the proposed method, the input image is segmented into foreground and Background image using edges, which are detected using canny edge detector and the residual image, is compressed using MFHW transform as shown in figure 2. From the input image the edges are detected initially, the edge detected images are traced to form the background and foreground image.

The valuable edge points are transmitted through the channel or stored separately in the buffer. The foreground image is transformed using MFHWT and coded using Bit plane encoder.
Algorithm

- Read the image and detect the edge of the image using canny detector.
- Store the valuable edge points in the buffer.
- Segment the image into foreground and background using the edges detected.
- Take the modified fast haar wavelet transform for the foreground image to extract the contrast information.
- Encode the Transformed coefficient using bit plane encoder, giving high importance to the foreground image.
- Transmit the valuable edge points and encoded information in the ideal noiseless channel.
- Perform decoding, inverse transform at the reconstruction side. Collect the edge information from the buffer.
- Trace the position of the edges.
- Map the pixel positions of the edges and the transformed coefficients.

IV. CONCLUSION

The compression ratio of proposed method is better than existing method. The quality of the image is also improved in proposed method than existing method in terms of PSNR. The edges are the important parameters in consideration of the peak signal-to-noise ratio values. The PSNR could be further increased by considering the background details and some high frequency components. The Proposed method is appropriate for larger insignificant background images and certain level of loss is tolerable in the background of the image. The proposed method can be extended for colour images rather than gray scale image. The method can also be extended with other features of the image.

REFERENCES


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