Efficient Image Compression Schemes: A Survey

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Abstract- Image compression assumes a vital part in medicinal imaging permitting productive capacity and transmissions by decreasing the measure of information required to speak to the computerized image. The principle objective is to accomplish higher compression proportions and least debasement in quality. To diminish the storage room, the utilization of various compression strategies is supported by some medicinal imaging modalities create the volume that of information which will be expanding. Distinctive therapeutic images like X-beam angiograms, attractive reverberation images, Ultrasound and figured Tomography are utilized as a part of the therapeutic image compression strategies. In medicinal applications it is required to moderate the analytic legitimacy of the image requires the utilization of lossless compression strategies, delivering low compression components. For therapeutic information, lossless compression is liked to the more prominent additions of lossy compression, in light of a legitimate concern for precision. . An arrangement of investigation has been performed for the examination of the proposed chip away at the few DICOM therapeutic images and it has been watched that the DWT, DCT and Huffman coding has higher compression proportion than the half and half model. The proposed technique gives better nature of image that incorporates high PSNR and CR and additionally low MSE. The proposed medicinal „DICOM images compression scheme‟ depends on Hybrid DWT, DCT and Huffman coding systems.

Keywords- Discrete cosine transform, Discrete wavelets transform, Lossy image compression, Singular value decomposition.

I. INTRODUCTION

Image compression is critical for proficient transmission and capacity of images . Request for correspondence of sight and sound information through the broadcast communications arrange and getting to the sight and sound information through Internet is developing explosively[14].With the utilization of advanced cameras, necessities for capacity, control, and exchange of advanced images, has developed violently . These image documents can be huge and can involve a ton of memory. A dark scale image that is 256 x 256 pixels has 65, 536 components to store, and an a run of the mill 640 x 480 shading image has about a million. Downloading of these records from web can be extremely tedious errand. Image information includes a critical segment of the mixed media information and they possess the real part of the correspondence transmission capacity for interactive media communication. Therefore advancement of proficient systems for image compression has moved toward becoming very necessary [9]. A typical normal for most images is that the neighboring pixels are exceedingly related and in this way contain exceedingly excess data. The fundamental goal of image compression is to discover an image portrayal in which pixels are less corresponded. The two key standards utilized as a part of image compression are repetition and immateriality. Repetition expels excess from the flag source and superfluity excludes pixel esteems which are not perceptible by human eye. JPEG what's more, JPEG 2000 are two imperative systems utilized for image compression. Take a shot at global models for image compression begun in the late 1970s with the CCITT (at present ITU-T) need to institutionalize twofold image compression calculations for Group 3 copy interchanges. From that point forward, numerous different advisory groups and guidelines have been framed to deliver by right norms, (for example, JPEG), while a few financially fruitful activities have viably moved toward becoming true measures, (for example, GIF). Image compression measures bring about many advantages, for example, (1) less demanding trade of image records between various gadgets and applications; (2) reuse of existing equipment and programming for a more extensive cluster of items; (3) presence of benchmarks and reference informational indexes for new and option advancements.

1.1 NEED FOR IMAGE COMPRESSION:

The need for image compression becomes apparent when number of bits per image are computed resulting from typical sampling rates and quantization methods. For example, the amount of storage required for given images is (i) a low resolution, TV quality, color video image which has 512 x 512 pixels/color,8 bits/pixel, and 3 colors approximately consists of 6 x10^6 bits;(ii) a 24 x 36 mm negative photograph scanned at 12 x 10^{-6}mm:3000 x 2000 pixels/color, 8 bits/pixel, and 3 colors nearly contains 144 x 10^6 bits; (3) a 14 x 17 inch radiograph scanned at 70 x 10^{-6}mm: 5000 x 6000 pixels, 12 bits/pixel nearly contains 360 x 10^6 bits. Thus storage of even a few images could cause a problem. As another example of the need for image compression ,consider the transmission of low resolution 512 x 512 x 8 bits/pixel x 3-color video image over telephone lines. Using a 96000 bauds(bits/sec) modem, the transmission would take approximately 11 minutes for just a single image, which is unacceptable for most applications.

1.2 PRINCIPLES BEHIND COMPRESSION:

Number of bits required to represent the information in an image can be minimized by removing the redundancy present in it. There are three types of redundancies: (i)spatial redundancy, which is due to the correlation or dependence between neighbouring pixel values; (ii) spectral redundancy, which is due to the correlation between different color planes or spectral bands; (iii) temporal redundancy, which is present because of correlation between different frames in images. Image compression research aims to reduce the number of bits required to represent an image by removing the spatial and spectral redundancies as much as possible.

Data redundancy is of central issue in digital image compression. If n1 and n2 denote the number of information carrying units in original and compressed image respectively ,then the compression ratio CR can be defined as

And relative data redundancy RD of the original image can be defined as

RD=1-1/CR;

Three possibilities arise here:

(1) If n1=n2,then CR=1 and hence RD=0 which implies that original image do not contain any redundancy between the pixels.

(2) If n1>>n1, then CR→∞ and hence RD>1 which implies considerable amount of redundancy in the original image.

(3) If n1<<n2,then CR>0 and hence RD→-∞ which indicates that the compressed image contains more data than original image.

1.3 TYPES OF COMPRESSION:

Lossless versus Lossy compression: In lossless compression schemes, the reconstructed image, after compression, is numerically identical to the original image. However lossless compression can only a achieve a modest amount of compression. Lossless compression is preferred for archival purposes and often medical imaging, technical drawings, clip art or comics. This is because lossy compression methods, especially when used at low bit rates, introduce compression artifacts. 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. Lossy methods are especially suitable for natural images such as photos in applications where minor (sometimes imperceptible) loss of fidelity is acceptable to achieve a substantial reduction in bit rate. The lossy compression that produces imperceptible differences can be called visually lossless[8].

Predictive versus Transform coding: 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 computational requirements.

Transformer: It transforms the input data into a format to reduce interpixel redundancies in the input image. Transform coding techniques use a reversible, linear mathematical transform to map the pixel values onto a set of coefficients, which are then quantized and encoded. The key factor behind the success of transform-based coding schemes is that many of the resulting coefficients for most natural images have small magnitudes and can be quantized without causing significant distortion in the decoded image. For compression purpose, the higher the capability. Of compressing information in fewer coefficients, the better the transform; for that reason, the Discrete Cosine Transform (DCT) and Discrete Wavelet Transform(DWT) have become the most widely used transform coding techniques.

Fig 1 Image Compression model

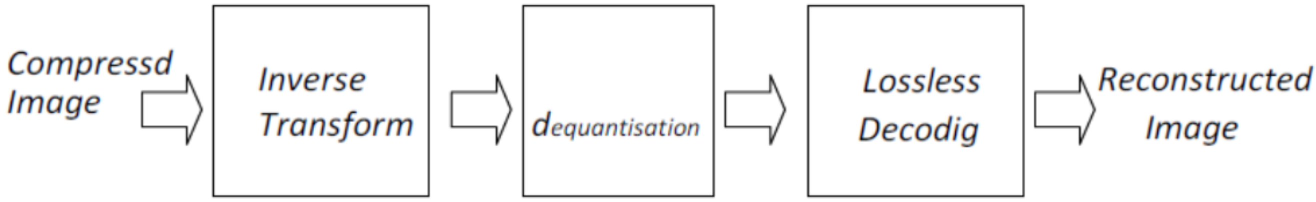

Fig 2 Image Decompression model

Transform coding algorithms usually start by partitioning the original image into subimages (blocks) of small size (usually 8 × 8). For each block the transform coefficients are calculated, effectively converting the original 8 × 8 array of pixel values into an array of coefficients within which the coefficients closer to the top-left corner usually contain most of the information needed to quantize and encode (and eventually perform the reverse process at the decoder's side) the image with little perceptual distortion. The resulting coefficients are then quantized and the output of the quantizer is used by symbol encoding techniques to produce the output bitstream representing the encoded image. In image decompression model at the decoder's side, the reverse process takes place, with the obvious difference that the dequantization stage will only generate an approximated version of the original coefficient values e.g., whatever loss was introduced by the quantizer in the encoder stage is not reversible.

QUANTIZER: It reduces the accuracy of the transformer's output in accordance with some preestablished fidelity criterion. Reduces the psychovisual redundancies of the input image. This operation is not reversible and must be omitted if lossless compression is desired. The quantization stage is at the core of any lossy image encoding algorithm. Quantization at the encoder side, means partitioning of the input data range into a smaller set of values. There are two main types of quantizers: scalar quantizers and vector quantizers. A scalar quantizer partitions the domain of input values into a smaller number of intervals. If the output intervals are equally spaced, which is the simplest way to do it, the process is called uniform scalar quantization; otherwise, for reasons usually related to minimization of total distortion, it is called non uniform scalar quantization. One of the most popular non uniform quantizers is the Lloyd- Max quantizer. Vector quantization (VQ) techniques extend the basic principles of scalar quantization to multiple dimensions.

Symbol (entropy) encoder: It creates a fixed or variable-length code to represent the quantizer's output and maps the output in accordance with the code. In most cases, a variable-length code is used. An entropy encoder compresses the compressed values obtained by the quantizer to provide more efficient compression. Most important types of entropy encoders used in lossy image compression techniques are arithmetic encoder, huffman encoder and run-length encoder.

II. SYSTEM MODEL

The discrete cosine transform is a fast transform that takes a input and transforms it into linear combination of weighted basis function, these basis functions are commonly the frequency, like sine waves.

It is widely used and robust method for image compression, it has excellent energy compaction for highly correlated data, which is superior to DFT and WHT. Though KLT minimizes the MSE for any input image, KLT is seldom used in various applications as it is data independent obtaining the basis images for each sub image is a non trivial computational task, in contrast DCT has fixed basis images. Hence most practical transforms coding systems are based on DCT which provides a good compromise between the information packing ability and computational complexity.

$$c(u) = a(u) \sum_{x=0}^{N-1} f(x) \cos[(2x+1)u\pi/2N]$$

where u=0,1,2,… … .,N-1

Inverse DCT is defined as

$$f(x) = \sum_{x=0}^{N-1} a(u)\, c(u) \cos[(2x+1)u\pi/2N]$$

where x=0,1,2,… … .,N-1

$$a(u) = \sqrt{1/N} \quad \text{for } u = 0$$

$$a(u) = \sqrt{1/N} \quad \text{for } u=1,2,3\ldots N-1$$

Compared to other independent transforms it has following advantages, can be implemented in single integrated circuit has ability to pack most information in fewer number of

coefficients and it minimizes the block like appearance, called blocking artifact that results when the boundary between sub images become visible.
One dimensional DCT is defined as:

The correlation between different coefficients of DCT is quite small for most of the image sources and since DCT processing is Asymptotically Gaussian. Those transformed coefficients are treated as they are mutually independent.

In general, DCT correlates the data being transformed so that most of its energy is packed in a few of its transformed coefficient's. The goal of the transformation process is to decorrelated the pixels of each sub images or to pack as much information as possible into the smaller number of transform coefficients. The Quantization stage then selectively eliminates or more coarsely quantizes the coefficients that carry the least information. These coefficients have the smallest impact on the reconstructed sub image quality. the encoding process terminates by coding the quantized coefficients.

2.1 COMPRESSION PROCEDURE

For a given image , you can compute the DCT of, say each row, and discard all values in the DCT that are less then a certain threshold. We then save only those DCT coefficients that are above the threshold for each row, and when we need to reconstruct the original image, we simply pad each row with as many zeroes as the number of discarded coefficients, and use the inverse DCT to reconstruct each row of the original image. We can also analyze image at the different frequency bands, and reconstruct the original image by using only the coefficients that are of a particular band. The steps for compression are as follows:

Step 1: Digitize the source image into a signal s, which is the string of numbers.

Step 2: Decompose the signal into a sequence of transform coefficients w.

Step 3: Use threshold to modify the transform coefficients from w to another sequence w′.

Step 4: Use quantization to convert w' to a sequence q.

Step 5: Apply entropy coding to compress q into a sequence e.

The detail compression steps are as follows:

Step 1: DIGITIZATION

The first step in the image compression process is to digitize the image. The digitized image can be characterized by its intensity levels or scales of gray which range from 0(black)

to 255(white), or its resolution, or how many pixels per square inch. Each of the bits involved

in creating an image takes up both time and money, so a tradeoff must be made.

Step 2: TRANSFORM

Apply DCT transform to each of the pixel values to get a set of transform coefficients. The basic motive behind transforming the pixels is to concentrate the image data spread over many pixels to a lesser number of pixels and then the pixels that do not contain and relevant data can be discarded, hence reducing the image size. Typically transforms applied are any functions that are invertible so that we can regenerate the transformed values and should be capable of concentrating the image data over a lesser area. The well known Discrete Cosine Transform and Discrete Wavelet Transform are few examples. The upcoming JPEG 2000 uses the Discrete Wavelet Transform for its compression.

Step 3: THRESHOLDING

In certain signals, many of the transform coefficients are zero. Through a method called threshold, these coefficients may be modified so that the sequence of transform coefficients contain long strings of zeros. Through a type of compression known as entropy coding, these long strings may be stored and sent electronically in much less space. There are different types of threshold. In hard threshold, a tolerance is selected. Any transform coefficient whose absolute value falls below the tolerance is set to zero with the goal to introduce many zeros without losing a great amount of detail. There is not a straightforward easy way to choose the threshold, although the larger the threshold that is chosen, the more error that is introduced into the process. Another type of threshold is soft threshold. Once again a tolerance h is selected. If the absolute value of an entry is less than the tolerance then that entry is set to zero. All other entries, d, are replaced with sign(d)||d|-h|. Soft threshold can be thought of as a translation of the signal toward zero by the amount h. A third type of threshold is quantile threshold. In this method a percentage p of entries to be eliminated are selected. The smallest (in absolute value) p percent of entries are set to zero.

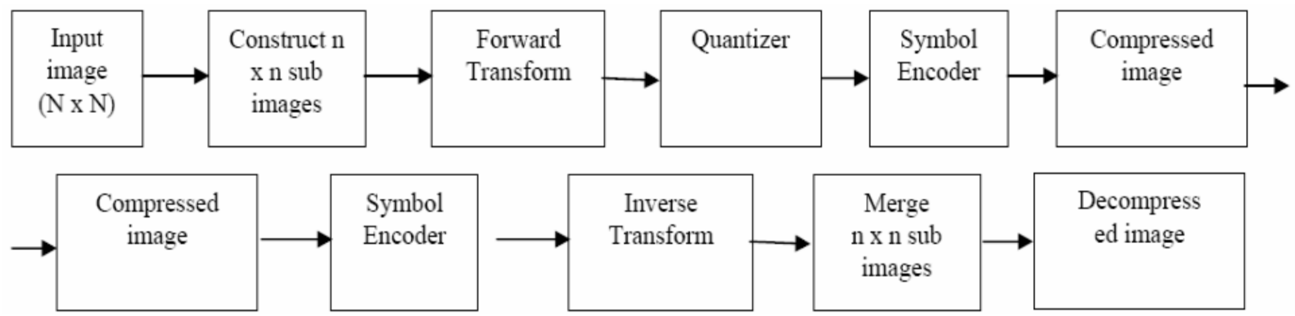

Fig 3 Steps for DCT compression

Step 4: QUANTIZATION

Quantization converts a sequence of floating numbers w' to a sequence of integers q. The simplest form is to round to the nearest integer. Another option is to multiply each number in w' by a constant k, and then round to the nearest integer. Quantization is called lossy because it introduces error into the process, since the conversion of w' to q is not a one-to-one function.

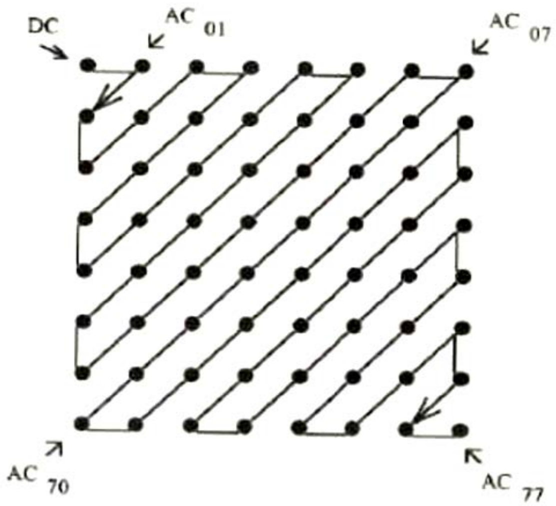

Fig 4 Zigzag scan

Step 5: ENTROPY CODING

Transforms and threshold help process the signal, but up until this point, no compression has yet occurred. One method to compress the data is Huffman entropy coding. With this method, an integer sequence, q is changed into a shorter sequence, e, with the numbers in e being 8-bit integers. The conversion is made by an entropy coding table. Strings of zeros are coded by the numbers 1 through 100, 105 and 106, while the non-zero integers in q are coded by 101 through 104 and 107 through 254. In Huffman entropy coding, the idea is to use two or three numbers for coding, with the first being a signal that a large number or zero sequence is coming. Entropy coding is designed so that the numbers that are expected to appear the most often in q need the least amount of space in e.

III. LITERATURE REVIEW

A.M. G. Hnesh and H. Demirel[1], "DWT-DCT-SVD based hybrid lossy image compression technique.It designed a new hybrid transform coding methodology for lossy image compression that integrates discrete wavelet transform, discrete cosine Transform and singular value decomposition methods is proposed. The proposed system has enhancements in both the compression ratio and the computational time. The results demonstrate the advantages of the proposed system in comparison to the previous discrete cosine transform and singular value decomposition systems, Improvements in both compression ratio and computational time have been reported.

S. Afrose, S. Jahan and A. Chowdhury[2], "A hybrid SVD-DWT-DCT based method for image compression and quality measurement of the compressed image,"In
this research work it introduces a hybrid technique for image compression, where the image has been compressed in each stages of image transformation. The proposed technique contains a combination of Singular Value Decomposition (SVD), Discrete Wavelet Transform (DWT) and Discrete Cosine Transform (DCT) for image compression. In the first SVD stage, the singular values of low rank matrices have been discarded from the original image. The middle stage is designed by simply taking the approximation band in DWT domain. Finally, the property of DCT has been applied. Experimental results show that the proposed hybrid algorithm performs well to achieve a high compression rate as well as a compatible quality.
H. S. Prasantha, H. L. Shashidhara and K. N. B. Murthy[3],"Image Compression Using SVD," It proposed a system that is well known that the images, often used in variety of computer applications, are difficult to store and transmit. One possible solution to overcome this problem is to use a data compression technique where an image is viewed as a matrix and then the operations are performed on the matrix. Image compression is achieved by using Singular Value Decomposition (SVD) technique on the

image matrix. The advantage of using the SVD is the property of energy compaction and its ability to adapt to the local statistical variations of an image. Further, the SVD can be performed on any arbitrary, square, reversible and non reversible matrix of m x n size. In this research work, SVD is utilized to compress and reduce the storage space of an image. In addition, the research work investigates the effect of rank in SVD decomposition to measure the quality in terms of MSE and PSNR

S. Sebastian and Manimekalai M. A. P[4], "Color image compression Using JPEG2000 with adaptive color space transform," In this research work it represents a study of color image compression based JPEG 2000 with color space transform and comparison with JPEG compression. The basis for the JPEG algorithm is the Discrete Cosine Transform (DCT) which extracts spatial frequency information from the spatial amplitude samples. These frequency components are then quantized to eliminate the visual data from the image that is least perceptually apparent, thereby reducing the amount of information that must be stored. Finally, the redundant properties of the quantized frequency samples are exploited through Huffman coding to produce the compressed representation. The JPEG-2000 which is based on the wavelet transform is a promising image compression technique expected to replace the current discrete cosine transform based compression known as JPEG. The approach based on JPEG 2000 has better compression performance. It has better compression ratio, good PSNR and low mean square error compared to JPEG compression.

IV. PROBLEM DESCRIPTION

In above work a novel DWT-DCT-SVD methodology for image compression has been proposed in order to get better performance. But in both cases systems are complicated in this work with the normal DCT compression used in the JPEG. For example at DCT-Threshold of τ=36, the proposed method reaches compression ratio of 46.91 where DCT-SVD reaches 44.74 and the traditional DCT method encountered only 38.13. Also with τ=36 proposed method takes 49.31 ms while DCT-SVD needs 75.39 ms. In our methodology we need to increase the better performance so that the system will get the higher compression ratios with faster computational time.

D. U. Shah and C. H. Vithlani[5], "FPGA realization of DA-based 2D-Discrete Wavelet Transform for the proposed image compression approach.It designed a system in which the lack of disk space seems to be a major challenge during transmission and storage of raw images, which in turn pushes the demand for an efficient technique for compression of images. Although, lot of compression techniques are available today, any upcoming technique which is faster, memory efficient and simple surely has the greatest probability to hit the user requirements. In this paper, we have developed wavelet-based image compression algorithm using well-known Distributed Arithmetic (DA) technique. Here, to increase the compression rate, the reduction of wavelet coefficients is carried out in each level of computation with the help of RW block proposed in the paper. After computing the DWT coefficients, we apply DPCM (Differential pulse-code modulation) which is a transformation technique for increasing the compressibility of an image. Finally, the transformed coefficients are given to Huffman-encoder that is designed by merging the lowest probable symbols in such a way that, the images will get compressed. For decompression, the Huffman decoding procedure is applied in the compressed image. Furthermore, the inverse DPCM and inverse DWT is applied on the decoded data to obtain the decompressed image. For implementation, the DA-based wavelet is simulated in Active HDL tool and the final design is verified with verilog test benches.

C. Vimalraj, S. S. Blessia and S. Esakkirajan[6], "Image compression using wavelet packet and singular value decomposition. Compression of digital images has been a topic of research for many years and a number of image compression standards have been created for different applications. It simulated the role of compression is to reduce bandwidth requirements for transmission and memory requirements for storage of all forms of data. The main objective is to study and implement the operations used in a lossy compression scheme to compress two-dimensional images. Basically, this scheme consists of three operations, which are the transform, quantization and entropy encoding operations. Wavelet Transform and Wavelet Packet Transform are efficient tools to represent the image. Wavelet Packet Transform is a generalization of Wavelet Transform which is more adaptive than the Wavelet Transform because it offers a rich library of bases from which the best one can be chosen for a certain class of images with a specified cost function. Wavelet Packet decomposition yields a redundant representation of the image. In this work, Singular Value Decomposition is used as a tool to select the best basis. After selecting the best tree, the coefficients of the best tree are quantized using dead zone quantization. To reduce the number of bits required to transmit the indexes of the codeword, a lossless Huffman algorithm was implemented as the final stage of the encoding process. To reconstruct the compressed image, the operations are reserved. The simulation result reveals that, the quantity of the image is good even though the compression ratio is increased due to reduction in Wavelet Packet sub-bands.

V. CONCLUSION

In the thesis image compression techniques using DCT and DWT were implemented. DCT is used for transformation in JPEG standard.DCT performs efficiently at medium bit rates. Disadvantage with DCT is that only spatial correlation of the pixels inside the single 2-D block is considered and the correlation from the pixels of the neighboring blocks is neglected. Blocks cannot be decorrelated at their boundaries using DCT. DWT is used as basis for transformation in JPEG 2000 standard. DWT provides high quality compression at low bit rates. The use of larger DWT basis functions or wavelet filters produces blurring near edges in images. DWT performs better than DCT in the context that it avoids blocking artifacts which degrade reconstructed images. However DWT provides lower quality than JPEG at low compression rates.DWT requires longer compression time.

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