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PERFORMANCE ANALYSIS OF DIFFERENT MATRIX ORDERED DISCRETE COSINE TRANSFORM BASED IMAGE COMPRESSION TECHNIQUES

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Abstract: **Image files can be compressed the different techniques. An compressing image is significantly different than compressing raw binary data. Image compression addresses the problem by reducing the amount of data required to represent a digital image. The uncompressed image data requires a large storage capacity and transmission bandwidth. The purpose of the image compression algorithm is to reduce the amount of data required to represents the image with less degradation in the visual quality and without any information loss. The discrete cosine transform (DCT) used to reduce the redundancy between the pixels and for energy compaction. It is used specially for the compression of images where tolerable degradation is required. With the wide use of computers and consequently need for large scale storage and transmission of data, efficient ways of storing of data have become necessary. In this paper the performance of discrete cosine transform based compression technique with different matrix order was analyzed. DCT with 8 x 8 block gives good compromise between information packing ability and computational complexity.**

Keywords: **Image Compression, Discrete Cosine Transform, symbol coding, Differential Pulse Code Modulation.**

1. INTRODUCTION

Image compression is very significant role for efficient transmission and storage of images. Communication of multimedia data through the telecommunications network and accessing that data by Internet is growing explosively [1]. In the use of digital cameras, requirements for storage, manipulation, and transfer of digital images, has grown explosively. These image files can be very large and can occupy a lot of memory. An gray scale image that is 256 x 256 pixels has 65 and a typical 640 x 480 color image has nearly a million. These files downloading from internet can be very time consuming task. Image data comprise of a important portion of the multimedia data and they occupy the major portion of the communication bandwidth for multimedia communication. An development of efficient techniques for image compression has become quite necessary [2]. A common characteristic of most images is the neighboring pixels are highly correlated and contain highly redundant information. The objective of image compression is to find an image representation in which pixels are less correlated. The two fundamental principles used in image compression are redundancy and irrelevancy. Redundancy removes from the signal source and irrelevancy omits pixel values which are not noticeable by eye.

2. THE NEED FOR IMAGE COMPRESSION

The image need for image compression becomes perceptible when number of bits per image are computed resulting from typical sampling rates and quantization methods. Regarding image quality, the most critical step in going from the analog world (cine film or high definition live video in the catheterization laboratory) to the digital world is the digitization of the signals. For this step, the basic requirement of maintaining image quality is easily translated into two basic quantitative parameters, (1) the rate of digital image data transfer or data rate (Mb/s) , (2) the total amount of digital storage required or data capacity (Megabyte). As a example, the spatial resolution of the cine film is generally assumed to be equivalent to a digital matrix of at least 1000 by 1000 pixels, each with up to 256 gray levels (one byte) of contrast information. The principal approach in data compression is the reduction of the amount of image data (bits) while preserving image details. This technology is a key enabling factor in many imaging and multimedia concepts outside of medicine. An x-ray images with a smaller matrix of just 512 by 512 pixels (instead of the 1024 by 1024 pixel matrix often applied for real-time displays). In order to objectively assess these and other techniques of image data compression, some systematic knowledge of the tradeoffs implied in different modes of image data reduction is mandatory.

3. TYPES OF COMPRESSION

When hearing that image data are reduced, one could expect that automatically also the image quality will be reduced. A loss of information is, however, totally avoided in lossless compression, where image data are reduced while image information is totally preserved.. Lossless compression is preferred for archival purposes and often medical imaging, drawings, picture, clip art. This is lossy compression methods, especially when used at low bit rates, introduce compression artifacts. Lossy data compression has of course a strong negative suggestion and sometimes it is doubted quite emotionally that it is at all applicable in medical imaging. 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 loss of reliability is acceptable to achieve a substantial reduction in bit rate. The lossy compression that produces unnoticeable differences can be called visually lossless[3].

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. This method provides greater data compression compared to predictive methods, although at the expense of greater computational requirements.

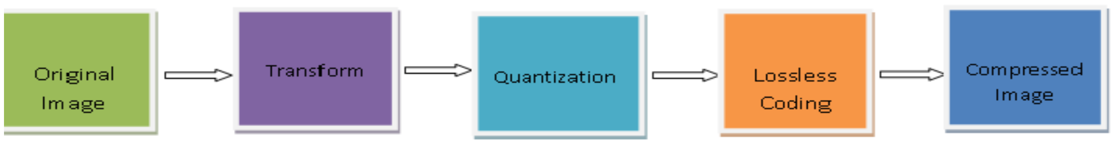

Figure 1: Image compression

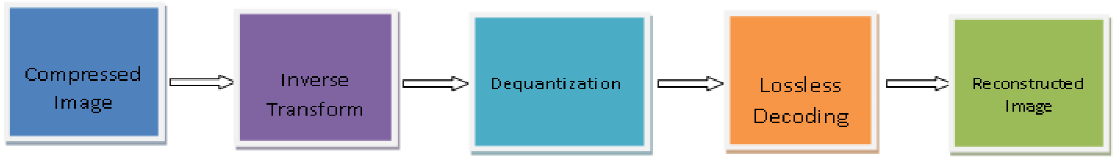

Figure 2: Image decompression

The following image compression methods are:

- Transformer
- Quantizer
- Symbol encoder.

Transformer: In transform method is give the input data into a format to reduce inter pixel 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. For compression purpose, the higher the capability. of compressing information in fewer coefficients, the better the transform. Discrete Cosine Transform (DCT)) have become the most widely used transform coding techniques. This coding algorithms usually start by partitioning the original image into small size of block. 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 the image with little perceptual distortion. In image decompression model at the decoder's side, the reverse process takes position, with the clear difference that the dequantization stage will only generate an approximated version of the original coefficient values.

Quantizer: A typical works by breaking the image into discrete blocks (8×8 pixels JPEG) These blocks can then be subjected to discrete cosine transform (DCT) to calculate the frequency components, both horizontally and vertically. The resulting block (the same size as the original block) is then pre-multiplied by the quantization scale code and divided element-wise by the quantization matrix, and rounding each resultant element. The quantization matrix is designed to provide more resolution to more perceivable frequency components over less perceivable components (usually lower frequencies over high frequencies) in addition to transforming as many components to 0, which can be encoded with greatest efficiency. The extent of the reduction may be varied by changing the quantizer scale code, taking up much less bandwidth than a full quantizer matrix.

Symbol encoder: One of the main types of entropy coding creates and assigns a unique prefix-free code to each unique symbol that occurs in the input. These entropy encoders then compress data by replacing each fixed-length input symbol with the corresponding variable-length prefix-free output codeword. The length of each codeword is approximately proportional to the negative logarithm of the probability. Therefore, the most common symbols use the shortest codes. An most common entropy encoding techniques are Huffman coding and arithmetic coding.

4. DISCRETE COSINE TRANSFORM

JPEG stands for the Joint Photographic Experts Group, a standards committee that had its origins within the International Standard Organization (ISO).JPEG provides a compression method that is capable of compressing continuous-tone image data with a pixel depth of 6 to 24 bits with reasonable speed and efficiency. Conversely, JPEG is capable of producing very high-quality compressed images that are still far smaller than the original uncompressed data.

JPEG is primarily a lossy method of compression. Slight changes in color are not perceived well by the human eye, while slight changes in intensity. Therefore JPEG's lossy encoding tends to be more frugal with the gray-scale part of an image and to be more playful with the color[4].DCT separates images into parts of different frequencies where less important frequencies are discarded through quantization and important frequencies are used to retrieve the image during decompression. Compared to other input dependent transforms, DCT has many advantages, such as : (1) It has been implemented in single integrated circuit; (2) It has the ability to pack most information in fewest coefficients; (3) It minimizes the block like appearance called blocking artifact that results when boundaries between sub-images become visible[5].

The forward 2Dimension DCT transformation is given by the following equation:

$$R(i,j)=T(i)T(j)\sum_{x=1}^{N-1}\sum_{y=1}^{N-1} f(x,y)\cos[(2x+1)i\pi/2N]\cos[(2y+1)j\pi/2N] \qquad \text{(Eqn-1)}$$

Where,i,j=0,1,2,3,……………,N-1

The inverse 2D-DCT transformation is given by the following equation:

$$f(x,y)=\sum_{i=1}^{N-1}\sum_{j=1}^{N-1} T(i)T(j)T(i,j)\cos[(2x+1)i\pi/2N]x\cos(2y+1)j\pi/2N] \qquad \text{(Eqn-2)}$$

where

T(i)=(1/N) ^1/2 for i=0

T(i)=2(/N)^1/2 for i=1,2,3…….,(N-1)

4.1 JPEG method:

Original image is divided into blocks of 8 x 8. Pixel values of a black and white image range from 0 to 255, but DCT is designed to work on pixel values ranging from -127 to 127 . so each block is modified within the range. DCT Ordered Algorithm is given below:

Step 1: Read a original Image.

Step2: Calculate DCT matrix using Eqn-1.

Step3 : DCT is applied to each block by multiplying the 4 x 4 block with DCT matrix.

Step 4: Each block is compressed by quantization.

Step 5: Quantized matrix is symbol encoded.

Step 6: Compressed image is reconstructed by reverse process.

Step 7: DCT is inversely using Eqn-2 for decompression.

4.2 Quantization:

Quantization is involved in image processing for lossy compression technique achieved by compressing a range of values to a single quantum value. When the number of discrete symbols in a given stream is reduced, the stream becomes more compressible. A quantization matrix is used in combination with a DCT coefficient matrix to carry out transformation. Quantization is the step where most of the compression takes place. DCT actually does not compress the image because it is almost lossless. Quantization makes use of the fact that higher frequency components are less important than low frequency components. It allows varying levels of image compression and quality through selection of specific quantization matrices. Therefore quality levels ranging from 1 to 100 can be selected, where 1 gives the poorest image quality and highest compression, while 100 gives the best quality and lowest compression. JPEG committee suggests matrix with quality level 200 as standard matrix [5].

4.3 Symbol Encoding:

An completed the quantization, most of the high frequency coefficients are zeros. To use the number of zeros, a zigzag scan of the matrix is used yielding to long string of zeros. A block has been converted to a spectrum and quantized, the JPEG algorithm takes the result and converts it into a one dimensional linear array of 64 co efficient values, performing a zigzag scan by selecting the elements in the numerical order indicated by the numbers in the 8 x 8 block grid below:

	0	1	2	3	4	5	6	7
0:	0	2	10	12	28	30	54	56
1:	4	8	24	26	32	52	58	84
2:	6	16	24	34	50	60	82	86
3:	18	22	36	48	62	80	88	106
4:	20	38	46	64	78	90	104	108
5:	40	44	66	76	92	102	109	118
6:	42	68	74	94	100	110	116	120
7:	70	72	96	98	112	114	122	124

Fig. 3: 8 x 8 block grid

This places the elements of the coefficient block in a reasonable order of increasing frequency by 2. Since the higher frequencies are more likely to be zero after quantization, this tends to group zero values in the high end of the vector [6].

5. EXPERIMENTAL RESULTS

Experimental results obtained after performing DCT of various orders on original images are shown. Fig. 4 shows cameraman original image. Image obtained after applying 8 x 8 DCT are as shown in Fig.5 whereas Fig.7 shows image obtained for same original image after applying 4 x 4 DCT. Similarly kids original image Fig.8 and Fige.10 are obtained after applying 8 x 8 DCT and 4 x 4 DCT of the image shown in Fig. 9 and Fig.11.

Fig.4 Original Image

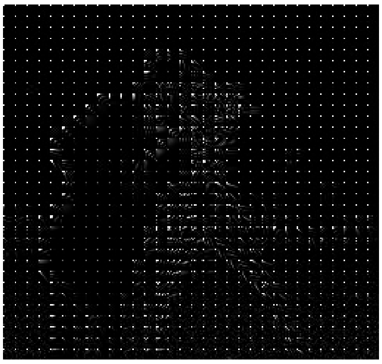

Fig.5 After compression of 8x8 Block

Fig.6 Original Image

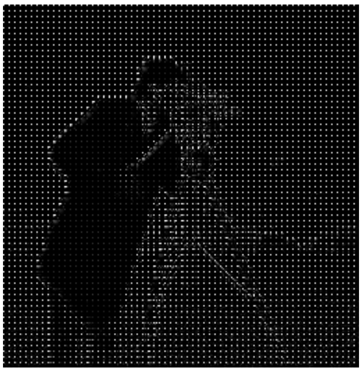

Fig.7After compression of 4x4

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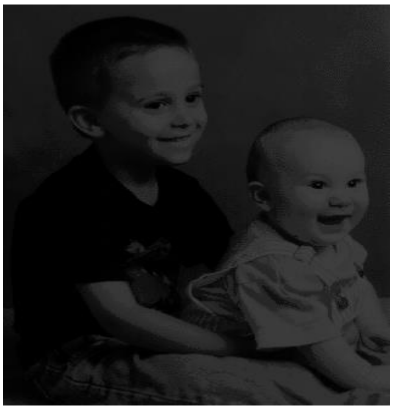

Fig.8 Original Image

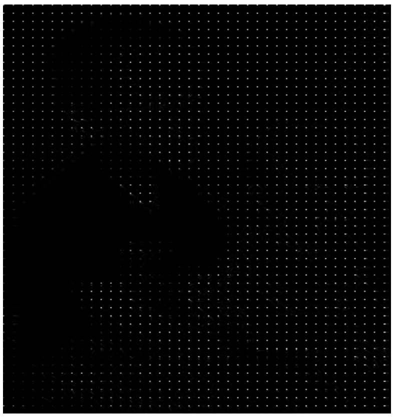

Fig.9 After compression of 8 x8

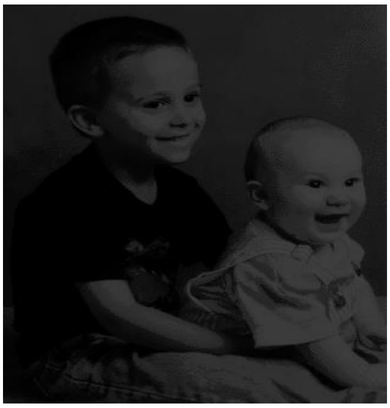

Fig.10 Original Image

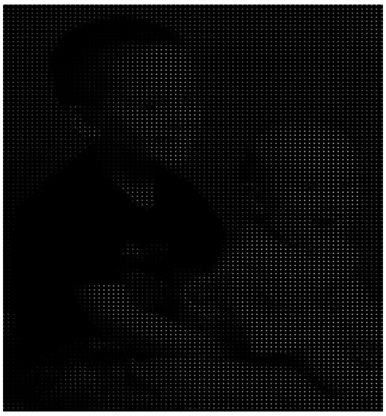

Fig.11 After compression of 4 x4

6. PERFORMANCE ANALYSIS

consider the mat lab simulation images make known that about 7.16 % compression ratio is achievable by DCT Ordered Algorithm for 8 x 8 block images and 4 x 4 block images the percentage is 4.01. Table 1 shows a portion of detailed results in case of gray-scale images. The term Compression Ratio is defined by given Equation .

Comperssion_Ratio = (Width * Height * BitDepth) / FileSize;

Table.1: CR Ratio between 8x8 block and 4x4 block for Gray-Scale Images

image	8 x 8 block			4 X 4 block		
	Total size	Total bits	CR	Total size	Total bits	CR
Cameraman	65240	4194304	8.03	65240	1048576	4.01
Kids	95162	8140800	10.69	95162	2035200	5.34
Lena	7068	3240000	7.16	7068	810000	7.16
mandi	6100662	391714944	8.02	6100662	97928736	4.01

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7. CONCLUSIONS

Image compression is used for managing images in digital format. This paper has been focused on the Fast and efficient lossless coding algorithms. JPEG for image compression using Discrete Cosine transform. we briefly introduced the various image compression model and the jpeg process steps including DCT, quantization , symbol encoding. DCT is used for transformation in JPEG standard.DCT performs efficiently at medium bit rates. 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.

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