Hybrid Image Compression Using HAAR and Approximate DCT

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Abstract: Image processing become a big provocation in the hypermedia usage for processing the images with lower power and higher efficiency. About an images to be refined, DCT(Discrete Cosine Transforms) are to make use for compression due to its benefit over the power energy utilization. In present methods, Approximation DCT along with fast algorithm and regular pipelining make-up for reduction change to the design complexities. In the cause of the recursive nature in the present design, high speed applications are becoming slow-moving. As an extension of this concept HAAR Wavelet transformation is used for better nature and accuracy of selected query image. HAAR wavelet method is more efficient than the Approximation in compressing color images. Here, image quality was closely maintained in difference with conservative method.

Keywords: DCT, HAAR Wavelet, Approximation, peak signal-to-noise ratio.

I. INTRODUCTION

The demand of multimedia applications has increased day by day. This is having an resulted video compression and image become important matter for reducing the transmission of the data as well as cost. Some of the familiar compression standards used now JPEG (Joint Photographers Expert Group), GIF (Graphics Interchange Format) although the recent researches are going to find even more enhanced compression standards. Main objective of compressing an image is to produce the image having less number of bits in accordingly for reducing the storage space and to decrease the transmission time without compromising image quality.

Mainly image compression categorized into two types they are, Lossless as well as Lossy. In lossless compression, the reconstructed image is numerically similar than that of the input image. Where as in lossy compression the reconstructed image contain some degradation. But this provides greater compression ratios than lossless technique. The easiest way of saving an image in pixels, but it is complicated. Larger image required more space to be stored. Instead of storing the pixel values directly different encoding schemes are adopted.

Such coding methods include Huffman Coding and (Graphics Interchange Format)GIF. Both of these are lossless methods. Other than these may cause the image data lose, but they results with less storage space. These algorithms include Fourier Transform, Cosine Transform, JPEG and Fractal Image Compression. JPEG stands for Joint Photographers Expert Group. This group was formed in 1980 which is a DCT-based image compression method used for still compressing an image. It has both lossless as well as lossy modes. JPEG is the most used format for storing and transmitting images in Internet. Although the use of JPEG standard has been very successful in several years, but it has some properties to improve. DWT became popular whenever fundamental shift in the image compression has come to approach, and it is adopted in the new JPEG 2000 standard. Another alternative method used to incur high compression ratio is Fractal Image Compression. This scheme was proposed by Arnaud Jacquin[1] and promoted by M. Barnsley[2]. It is based on the iterated function systems which utilize the self-similarities within the image. Basically it works by splitting image into blocks called range and domain and using Mapping methods to map range blocks into domains. But encoding of this method is more time consuming because of finding the most suitable range-domain pair. But the decoding is more simple than encoding. Due to this unsymmetrical nature this compression not widely used. But now a day several methods are proposed to improving its performance.

II. RELATED WORK

(a) DCT image compression

With the help of Discrete Cosine Transform (DCT) image can be divided into parts (or spectral sub-bands) of variating importance (in according to the image's visual quality).The discrete Fourier transform and The DCT are same in some cases: Signal or image from the spatial domain to the frequency domain can be transformed, as shown below:

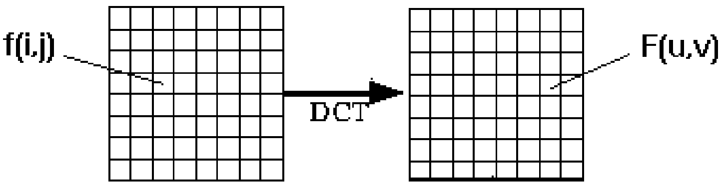


Fig 1. Signal transformation

(i) **DCT Encoding:**

The generalized eq : for a 1Dimension (*N* data items) Discrete Cosin Transform(DCT) is given by equation:

$$F(u) = \left(\frac{2}{N}\right)^{\frac{1}{2}} \sum_{i=0}^{N-1} \wedge(i).\cos\left[\frac{\Pi.u}{2.N}(2i+1)\right] f(i)$$

and respective *inverse* 1Dimension DCT transform is simple $F^{-1}(u)$ is given by

$$\Lambda(i) = \begin{cases} \frac{1}{\sqrt{2}} & \text{for} \xi = 0 \\ 1 & \text{otherwise} \end{cases}$$

general equation for a 2Dimension (*N* by *M* image) DCT is defined by the below equation:

$$F(u,v) = \left(\frac{2}{N}\right)^{\frac{1}{2}} \left(\frac{2}{M}\right)^{\frac{1}{2}} \sum_{i=0}^{N-1} \sum_{j=0}^{M-1} \wedge(i).\wedge(j) \cos\left[\frac{\Pi.u}{2.N}(2i+1)\right] \cos\left[\frac{\Pi.v}{2.M}(2j+1)\right].f(i,j)$$

and the corresponding inverse 2Dimension DCT transform was simple $F^{-1}(u,v)$.

Operations involved in the DCT as follows:

- Initially i/p image is N x M;
- Intensity of the pixel is f(i, j) { i^{th} row and j^{th} column } .
- F(u,v) is the DCT coefficient in (k1, k2) , row and column respectively.
- For most of the input image elements, high signal energy lies at lower frequencies, these become visible in the top- left corner of the DCT.
- Compression is brought out when, the lower right values shows the maximum frequencies, and are many times very small adequate to be skipped with the respect to observable distortion.
- DCT i/p is an 8 x 8 array of integers. This array having different gray scale levels of pixel's.
- 0 – 255 levels are containing in 8-bit pixel.

STEPS:

1. The image that may be either colour or greyscales is firstly split into k x k pixel blocks (usually k=8).
2. From topside to bottom and from left side to right, the DCT is applied to each image block.
3. Then result in k x k coefficients (so 64 for k=8) are quantized to lessen the vastness.
4. Consequently array of blocks that are compressed shows, compressed image i.e. the stored or image that was transmitted.
5. To get back the original image, the compressed image (array of blocks) is decompressed using Inverse DCT (IDCT).

(a) 2Coeff Retained (PSNR=21.8338) **(b) 6Coeff Retained (PSNR=22.2494)** **(c) 10 coeff retained (PSNR=24.6106)** **(d) 14 coeff retained (PSNR=25.010)**

(e) 18 coeff retained (PSNR=25.5893) **(f) 20 coeff retained (PSNR=25.8709)** **(g) 24 coeff retained (PSNR=25.9415)** **(h) 32 coeff retained (PSNR=27.8644)**

Fig.2 : Results of Lena Images after retaining different number of DCT Coefficients

Compression performance evaluated for gray scale images and that cab be grouped to three image types namely lower frequency (LF), Medium frequency(MF) and higher frequency (HF) images. DCT was implemented in Matlab and the performance calculating parameters like Peak Signal - Noise Ratio (PSNR) is determined. And the image element format was Bit map format (BMP)

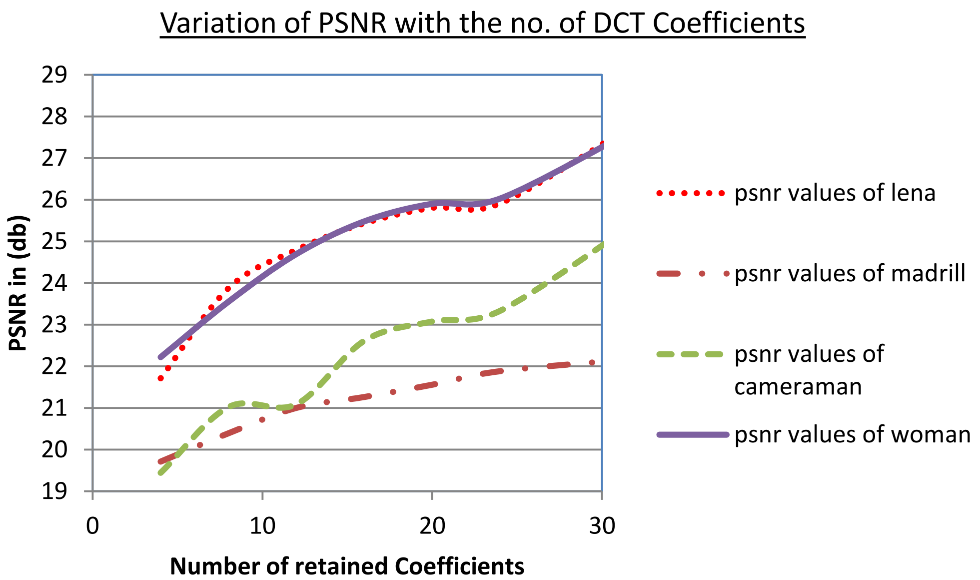


Fig.3 : Plot showing the PSNR variation with No. of retained Coefficients

Results are plotted where the PSNR of every method is taken against the number of Retained coefficients DCT (RC) that are helpful in the quantized level compression. The (Peak signal-to-noise ration)PSNR is found from the Mean Square Error (MSE) that was given by

$$MSE = \frac{1}{m*n}\sum_{x=1}^{m}\sum_{y=1}^{n}(p_{x,y} - \hat{p}_{x,y})^2$$

Here, accurate pixel value is $p_{x,y}$ where as row and column represents x and y respectively. $\hat{p}_{x,y}$ is the near by value of the same pixel, image size is carried out with the help of image elements.

- **Peak Signal-to-Noise Ration(PSNR) :**

$$\text{PSNR} = 10\log\frac{(2^n - 1)^2}{MSE}$$

Where $p_{x,y}$ → Exact pixel value at row (x) and column (y) of the image.

$\hat{p}_{x,y}$ → Close to the actual value of the same pixel, m and n are the image sizes.

(b) INEXACT ADDITION AND APPROXIMATE DCT

XOR and XNOR(Arithmetic circuits) well matched with inexact computing, approximate adders had been immense analyzed in the technical survey and is one of the basic arithmetic-operations in a large number of application of In-exact computing [3]. The action in circuit complexities at transistors level of an adder circuitry generally gives a better performance in power dissipation, many times more than the ordinary lower power structural ability [1]. In-exact adder design had assess in [2]: In-exact method been taken over with the modification of the exact cells of a modular adder design with an approximation of a cell with less complexity, or to generate and propagation of the carrier in the arithmetic process.

III. PROPOSED METHODOLOGY:

a) HAAR Wavelet Transformation:

The family of N HAAR functions $h_k(t)$, (k=0, …, N-1) are represented with an interval $0 \le t \le 1$. The shape of the specific function $h_k(t)$ of a given $k \ge 0$ index *k* depends on two parameters *p* and *q*, $k = 2^p + q - 1$: For any value of $k, k \ge 0$, *p* and *q* are uniquely determined so that 2^p is the largest power of 2 contained in k ($2^p < k$) and q-1 is the remainder, $q-1 = k - 2^p$.

For given N value the following p and q values are shown below:

K	**0**	**2**	**4**	**6**	**8**	**10**
P	0	1	2	2	3	3
Q	0	1	1	3	1	3

Table : Represents p and q values with respect to N and index=k

Now the HAAR functions can be defined recursively as:

- When *k*=0, HAAR function is shown as constant

  $$h_0(t) = 1/\sqrt{N}$$

- When *k* > 0, HAAR function is given by
  It shows that *P* represents the amplitude and width of the function (i.e.,non zero part).

- Where as *q* represents the non-zero part of the function as a position .

b) HAAR Matrix :

N HAAR function could be sampled at *t=m/N* , for discrete HAAR transform where m= 0,…, N-1 to get an *N* x *N* matrix. For eg : when *N*=2, we represent

$$H_2 = \frac{1}{\sqrt{2}}\begin{bmatrix} 1 & 1 \\ 1 & -1 \end{bmatrix}$$

when N=4, we have

$$H_4 = \frac{1}{2}\begin{bmatrix} 1 & 1 & 1 & 1 \\ 1 & 1 & -1 & -1 \\ \sqrt{2} & -\sqrt{2} & 0 & 0 \\ 0 & 0 & \sqrt{2} & -\sqrt{2} \end{bmatrix}$$

and when N=8

$$H_8 = \frac{1}{\sqrt{8}} \begin{bmatrix} 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 & -1 & -1 & -1 & -1 \\ \sqrt{2} & \sqrt{2} & -\sqrt{2} & -\sqrt{2} & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & \sqrt{2} & \sqrt{2} & -\sqrt{2} & -\sqrt{2} \\ 2 & -2 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 2 & 2 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 2 & -2 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 2 & -2 \end{bmatrix}$$

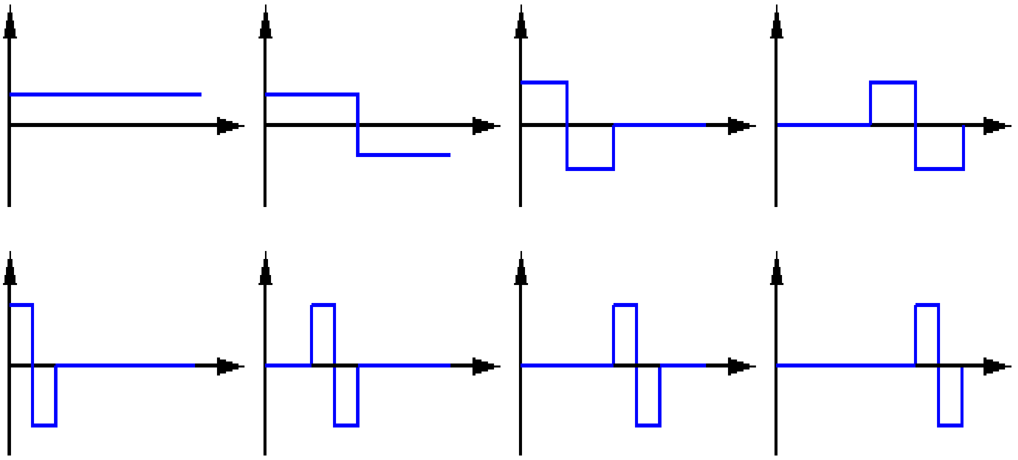


Fig. 4 : prototype shaped square wave and its inverse version

We see that all HAAR functions $h_k(t)$, $k>0$ having an single prototype shape composed of square wave and its negative version, and parameters

- *p* means magnitude and width (scale) of the shape.
- *q* means position (or shift) of the shape.

Note : The functions $h_k(t)$ of HAAR Transform can show not only the information in the signal of different scales (related to different frequencies) and also their locations in time.

Two additional parameters are taken in order to observe the resulting quality. They are Average-Difference (AD) and the Maximum-Absolute Difference (MD). These are mentioned as :

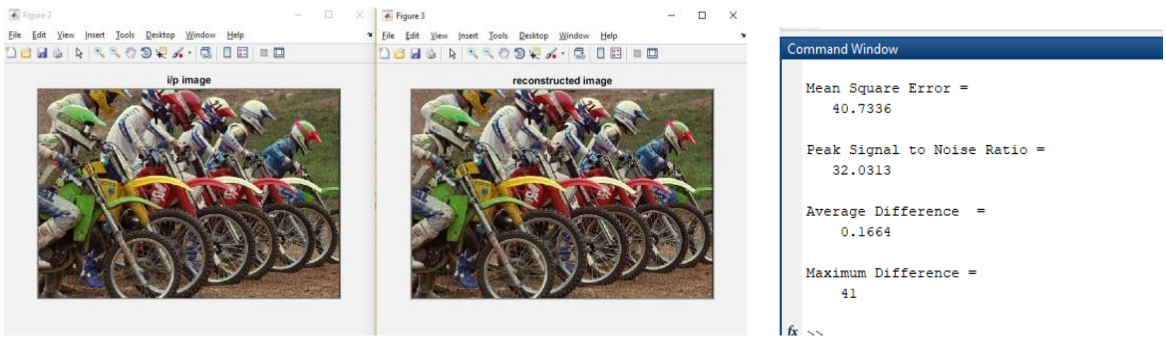
$$AD = \frac{1}{m*n}\sum_{j=1}^{m}\sum_{k=1}^{n}(p_{x,y} - \hat{p}_{x,y})$$

$$MD = \max_{m,n}\{|\, p_{x,y} - \hat{p}_{x,y}\,|\}$$

Here, Accurate pixel value is $p_{x,y}$ where as row and column represents x and y respectively. $\hat{p}_{x,y}$ is the approximate value of the same pixel, image size is carried out with the help of rows and columns (m,n)

Matlab Simulation Results :

Initially compression is carried out between Input image and the distortion image. So, Original image was taken to input image, distortion image gives reconstructed image. Where the performance calculation parameters are measured with the help of distorted image.



(a) (b) (c)

Fig.5 : (a)Given Input image, (b) Reconstructed output image (c) Parameters calculation like Mean Squared error, Peak signal-to-noise ratio, Average-Difference, Maximum-Difference .

IV. CONCLUSION:

Mainly the observation taken over regarding the arithmetic parameters, that are source of image element blocks of digital systems but in general shows minor fraction of the whole circuit. This analysis the methods to represents the DCT accerlators using the gate level-pruning. HAAR compression ratio performance and DCT is compared an analyzed the best method for digital image compression. Further KLT and SVD methods are can be applied for better performance.

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