IJETST- Volume||01||Issue||04||Pages 538-542||June||ISSN 2348-9480 2014

Open access Journal

International journal of Emerging Trends in Science and Technology

Information Packing Ability of Transformations in Image Processing

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Abstract **-** *Image speaks more than words!* We are dealing with images from Mars to Hollywood with a stop at the hospital.All of these images are compressed with the same amount of information while coming to us. So we need compression and in compression we need to deal with many transformations. Hence we will decide and choose the transformation which gives the best energy compaction. Energy compaction is the ability to pack energy of the spatial sequences into as few frequency coefficients as possible. It is important in image compression. If compaction is high, we only have to transmit a few coefficients instead of the whole set of pixels. So we will compare the result of all data of available many transformations. We will use MATLAB for the same.

Keywords **-** Image processing, compression of image, energy compaction, Transformation

1. INTRODUCTION

Data compression is a process of converting data files into smaller files for efficiency of storage and transmission. As one of the enabling technologies of the multimedia revolution, data compression is a key to rapid progress being made information technology. It would not be practical to put images, audio and video alone on websites without compression. Many people may have heard of *JPEG* (Joint Photographic Expert Group) and *MPEG* (Moving Pictures Expert Group), which are standards for representing images and video. So study is conducted to know how various *transformations are being performed in JPEG.*

2. SUBJECTS AND METHODS

Below is the procedure done in block transformation coding .

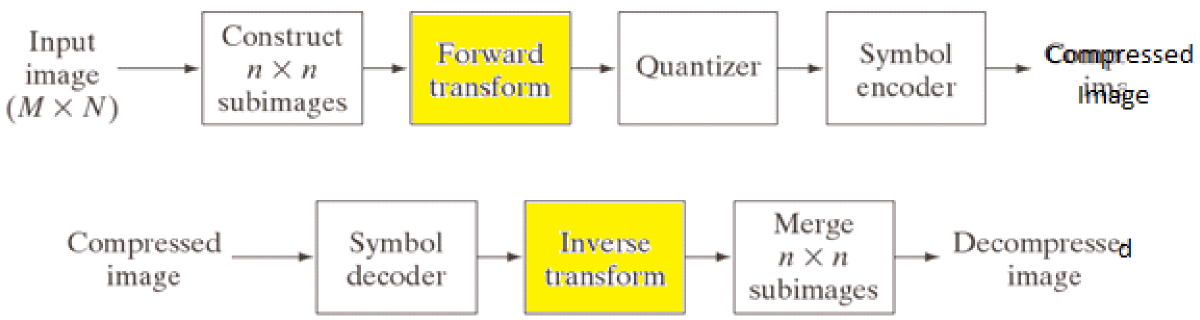

Fig. 1.1 Block Transformation Coding

Block transformation coding systems based on a variety of 2-D transforms. The choice of a particular transform in a given application depends on the amount of reconstruction error that can be tolerated.

Fig.1.2 Block Transformation

2.1 Various Transformations

Consider a sub image of $n \times n$, $g(x,y)$ whose forward and inverse transforms are as follows:

$$T(u,v) = \sum_{x=0}^{n-1} \sum_{y=0}^{n-1} g(x,y)\ r(x,y,u,v) \text{ (Forward)} \qquad (1)$$

$$g(x,y) = \sum_{u=0}^{n-1} \sum_{v=0}^{n-1} T(u,v)\ s(x,y,u,v) \text{ (Inverse)} \qquad (2)$$

Where $r(x,y,u,v)$ and $s(x,y,u,v)$ are forward and inverse transformation kernels respectively. They are also referred as basis function or basis images.

2.1.1 Discrete Fourier Transformation (DFT): Due to its computational efficiency DFT is very popular. This transformation yields complex transform $T(u,v)$ with even-odd symmetry in the real and imaginary components. It has,

$$r(x,y,u,v) = e^{-i2\pi(ux+vy)/n};$$

$$s(x,y,u,v) = \frac{1}{n^2} e^{i2\pi(ux+vy)/n} ;$$

2.1.2 Discrete Cosine Transformation (DCT): This transformation yields real valued transform $T(u,v)$. It has, $r(x,y,u,v) = s(x,y,u,v) =$

$$\propto (u) \propto (v) cos\left[\frac{(2x+1)\pi u}{2n}\right] cos\left[\frac{(2y+1)\pi v}{2n}\right]$$

$$Where, \propto (u) = \begin{cases} \sqrt{1/n} ; u = 0 \\ \sqrt{2/n} ; u > 0 \end{cases}$$

2.1.3 Walsh Hadamard Transform (WHT): This transformation yields real valued transform $T(u, v)$ *as*

$$r(x, y, u, v) = s(x, y, u, v) = H_m \, ; \quad Where,\, H_m = 2^{-1/2} \begin{bmatrix} H_{m-1} & H_{m-1} \\ H_{m-1} & H_{m-1} \end{bmatrix}$$

This is non sinusoidal transformation.

2.2 Root Mean Square Error (e_{rms}) :

Error is the measure of difference between original image and compressed image. Mean square is the cumulative squared error between the compressed image and original image. For the lesser distortion and high output quality, the MSE must be as low as possible. Mean Square Error may be calculated using expression:

$$e(x, y) = f'(x, y) - f(x, y);$$

Where $f'(x, y)$ is compressed image and $f(x, y)$ is t original image

So the total error is: $\sum_{x=0}^{M-1} \sum_{y=0}^{N-1} [f'(x, y) - f(x, y)]$

Here the images are of size$M \times N$.

The root-mean-square-error, e_{rms}, between $f'(x, y)$ and $f(x, y)$ is the square root of the squared error averaged over $M \times N$ and given as follows:

$$e_{rms} = [\frac{1}{MN}\text{:} \sum_{x=0}^{M-1} \sum_{y=0}^{N-1} [f'(x, y) - f(x, y)]^2]^{1/2}$$

2.3 How to select transformation?

To choose transformation we need to check the amount of associated information with each of them. Hence we need to calculate $T(u, v)$ for each $n \times n$ block of the image and then inverse transform of each and then Calculate e_{rms} error of resulting image.

Consider the following image results (Lena Image): **Comparison results of Transformation**

DFT WHT CDT

e_{rms} = 2.3 e_{rms}=1.78 e_{rms}=1.13

3. RESULTS

So the image results showed that the information packing ability of the *DCT* is superior to that of *DFT* and *WHT*. Image result *4.1* shows that after decoding, the *DCT* based result had the smallest e_{rms}, indicating that with respect to the e_{rms} the least amount of information was discarded. Also if we compare the periodicity of the sinusoidal transformations (*DFT* & *DCT*), DFT gives rise to boundary discontinuities while *DCT* has not that disadvantage.

That means in *DFT*, we are assuming that the second pixel is same as first pixel, it is not very probable. While *CDT* is not doing the same practise with the pixels. Also the *rms* is lesser in *DCT* compared to other two transformations. This is the reason why the *DCT* is much more efficient in block transformation coding.

Hence most transformation coding systems are based on the *DCT*, which provides a good compromise between information packing ability and computational complexity compared to the other input dependent transformations; it has the advantages of having been implemented in a single integrated circuit, packing the most information into lowest coefficients.

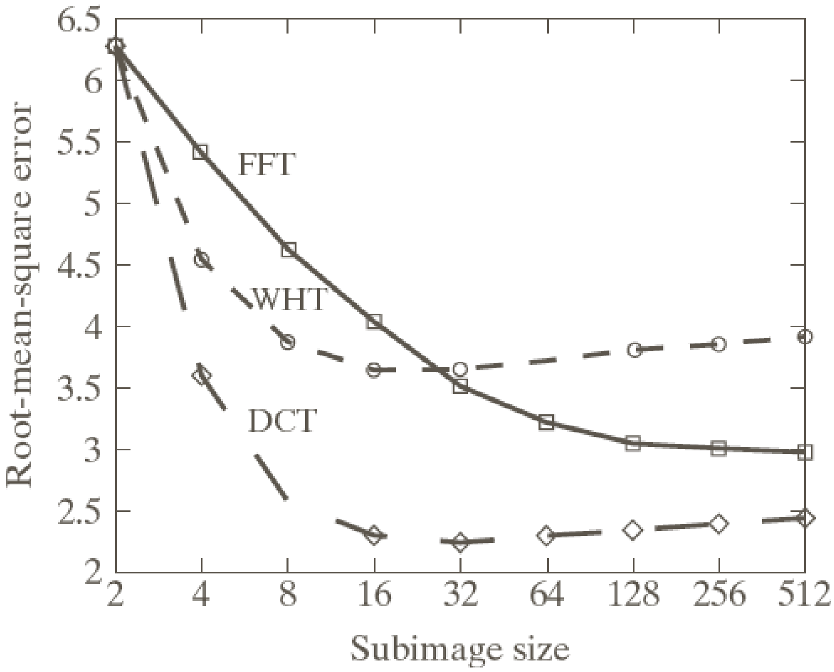

Fig. 5.1 Graph of e_{rms} and Sub image size

So by the figure 5.1 it is very clear that the properties of *DCT* are very useful and because of these properties *DCT* has become an international standard for transformation coding systems.

In this section, we described block transform coding, the image compression technique used by *JPEG* and *MPEG*.

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