Performance Comparison of DCT Based Image Compression on Hexagonal and Rectangular Sampling Grid

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***Abstract*-The advantages of processing images on hexagonal lattice are higher degree of circular symmetry, uniform connectivity, greater angular resolution, and a reduced need of storage and computation in image processing operations. In this work a comparison of DCT based Image compression on hexagonal and rectangular sampling grid is performed. DCT based image compression is performed on both rectangular domain and hexagonal domain using alternate pixel suppressal method. Mean Square Error and Peak Signal to Noise Ratio is considered for the performance analysis. Compression on hexagonal domain gives better results compared to compression on rectangular domain**

***Index Terms*—Image resampling, Compression, DCT, Hexagonal Image, Alternate pixel**

I. Introduction

The process of reducing the amount of data required to represent a given quantity of information is commonly known as compression. Even though, the storage space and transmission bandwidth can be reduced by compression, it will reduce the image fidelity, especially when the images are compressed at lower bit rates. Discrete Cosine Transform (DCT) based compression is an effective way of compression in which good compression ratio without losing too much of information can be obtained.

DCT convert images from time domain to frequency domain. That means DCT express the image in terms of sum of cosine functions at different frequencies. The JPEG process is a widely used form of lossy image compression which is based on DCT. The DCT transformation is reversible. The DCT works by separating images into parts of differing frequencies. During the process called quantization, the less important frequencies are discarded, and the most important frequencies that remain are used to represent the image.

In hexagonal domain DCT based compression is performed on the hexagonally sampled images. In this paper I propose the image compression based on DCT on the hexagonally sampled image. Resampling is the process of transforming a discrete image which is defined at one set of coordinate locations to a new set of coordinate points i.e, converting from rectangular to hexagonal grid [1]. The Fig.1 shows the system diagram for performing compression on hexagonal sampling grid. Golay [2] has proved that hexagonal pixel representation is very suited for image processing. Mersereau [3] has shown that 13.4% fewer sampling points are required with the hexagonal grid to maintain equal high frequency image information with the rectangular grid.

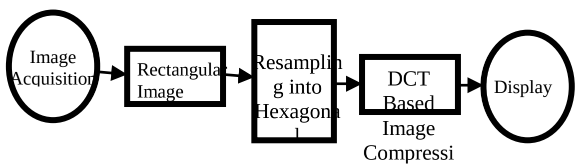

Figure 1. The system diagram for performing compression on hexagonal sampling grid.

II. DCT Based Image Compression On Hexagonal Sampling Grid

The Discrete Cosine Transform (DCT) transforms the time domain input into a linear combination of weighted basis functions. These basis functions are commonly the frequency components of the input. Since image is two dimensional we use 2-D Discrete Cosine Transform, which is just a one dimensional DCT applied twice, once

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in the ‘x’ direction, and again in the ‘y’ direction. The DCT equation, Equ.1, computes the i^{th} and j^{th} entry of the DCT of an image

$$D(i,j) = \frac{1}{\sqrt{2N}} c(i)c(j) \sum_{x=0}^{N-1} \sum_{y=0}^{N-1} p(x,y) cos\left[\frac{(2x+1)i\pi}{2N}\right] cos\left[\frac{(2y+1)j\pi}{2N}\right] .. (1)$$

$$C(u) = \begin{cases} \frac{1}{\sqrt{2}} if\ u = 0 \ldots\ldots\ldots & \ldots .(2) \\ 1\ if\ u > 0 \end{cases}$$

Following are the steps involved in DCT based image compression.

(1).The image is broken into 8x8 blocks of pixels. (2). Working from left to right, top to bottom, the DCT is applied to each block. (3).Each block is compressed through quantization. (4).The array of compressed blocks that constitute the image is stored in reduced amount of space.

Two different types of representation of hexagonal lattice are alternate pixel suppressal method and half-pixel shift method [4], [5]. In this work DCT based compression is performed on hexagonal grid representation, which is based on alternate pixel suppressal method. Hexagonal grid image based on alternate pixel suppressal method can be obtained from the conventional image by alternatively suppressing rows and columns of the existing rectangular grid and sub sampling it [6]. All the other pixels of the rectangular grid which do not have any correspondence with the hexagonal counterparts are suppressed to zero. While processing this sub sampled image the suppressed pixels are not considered in computation. The sub sampled hexagonal grid is shown in Fig. 2

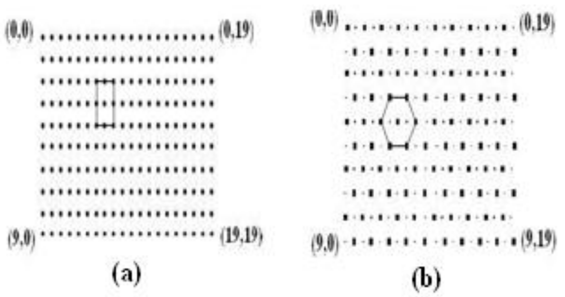

Figure 2. (a) Rectangular grid (b) Simulated grid obtained using alternate pixel submission.

III. Performance Comparison

The performance of DCT based image compression on rectangular and hexagonal grids is compared in this work. Mean Square Error (MSE) and Peak Signal to Noise Ratio (PSNR) are used for the performance comparison.

MSE indicate the average difference of the pixel throughout the image. If MSE is higher the difference of the pixel between the original and the processed image is also higher. The equation for MSE is shown in Equ. 3

$$MSE = \frac{1}{N} \sum_i \sum_j \left(Q_{ij} - P_{ij}\right)^2 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

Where N is the size of the image, Q and P are the processed and the original image respectively.

$$PSNR = 10log_{10}\left(\frac{N * 255^2}{\sum_i \sum_j (Q_{ij} - P_{ij})^2}\right) \ldots\ldots\ldots.. (4)$$

PSNR is used for quantitative comparison

IV. Results And Discussion

DCT based compression of image on rectangular and hexagonal grid are performed and it is compared based on MSE and PSNR. The results obtained is shown in Table.1

TABLE I. Test Results Comparison

Test Images	Sampling	MSE	PSNR
water.png	Rectangular	230.30	24.51
	Hexagonal	191.30	25.31
lena.gif	Rectangular	249.5	24.16
	Hexagonal	207.5	24.97

The results show that, DCT based compression on hexagonal grid image produces better results than on rectangular grid image. The comparison shows that, hexagonal grid gives better PSNR and also reduced MSE for hexagonal grid. Fig. 3 and Fig. 4 shows the original and the compressed images in rectangular and hexagonal domain for two different test images.

Figure 3. (a)Image (water.png) in Rectangular Grid.

Figure 4. (b) Compressed Image (water.png) in Rectangular Grid.

Figure 5. (c) Image (water.png) in Hexagonal Grid.

Figure 6. (d)Compressed Image (water.png) in Hexagonal Grid.

Figure 7. (a) Image (lena.gif) in Rectangular Grid.

Figure 8. (b) Compressed Image (lena.gif) in Rectangular Grid.

Figure 9. (c) Image (lena.gif) in Hexagonal Grid.

Figure 10. (d) Compressed Image (lena.gif) in Hexagonal Grid.

V. CONCLUSION

In this work DCT based image compression is performed on both rectangular grid and hexagonal grid images. The performance is studied using MSE and PSNR. Performance comparison shows better results for DCT based image compression in hexagonal grid images. Also from the graph we can see that in the case of hexagonal image, as the CR increases the PSNR does not decreases much, where as in conventional square pixel images PSNR goes down as CR increases. So by using hexagonal domain in image compression it is possible to get better results.

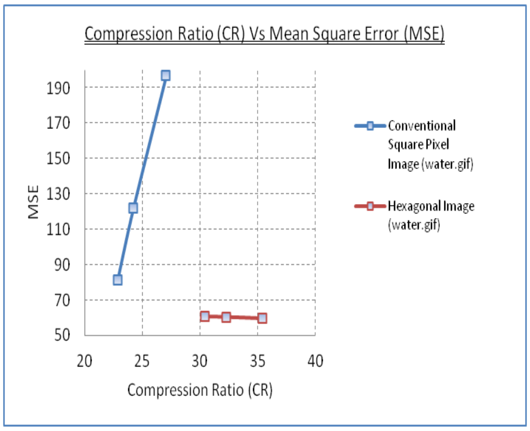

Figure 11. Graph of CR v/s MSE for the image water.gif.

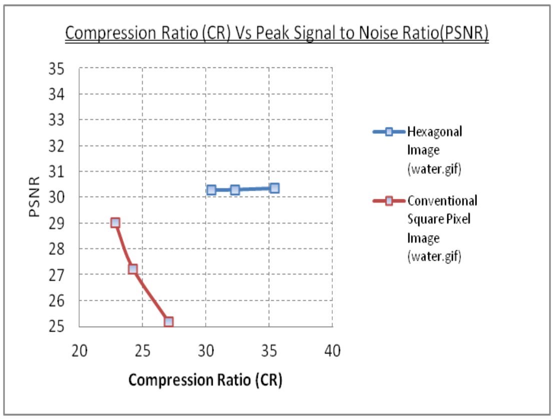

Figure 12. Graph of CR v/s PSNR for the image water.gif.

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