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NOVEL ALGORITHMS FOR FINDING AN OPTIMAL SCANNING PATH FOR JPEG IMAGE COMPRESSION

Smila Mohandhas and Sankar. S
Student , Computer Science and Engineering, KCG College of Engineering, Chennai.
Associate Professor, Computer Science and Engineering, KCG College of Engineering, Chennai.

Abstract— **The storage space and transmission time for images had become very high due to the usage of internet applications. In order to reduce both space and time and to increase the transmission speed, image compression techniques are applied. The main objective of the study is to design and implement different zigzag scanning paths. Different types of zigzag scan paths namely ZzRotateLeft90º, ZzRotateRight90º, ZzRotate180º, ZzVertical are used here. The performance analysis of the scanning paths is done based on the two factors PSNR (Peak Signal Noise Ratio) and CR (Compression Ratio).**

***Index Terms*— Image compression, Zigzag scan, PSNR, CR** *(key words)*

I. INTRODUCTION

Images are easier to represent and interpret than text documents. But images occupy more space while downloading or uploading for internet applications. The storage space and time becomes more complex due to huge size. In order to reduce the size and time some image compression techniques are applied. Some of the applications of image compression are TV broadcasting, remote sensing, radar, teleconferencing, weather maps, geological surveys, etc. There are three purposes for which the image compression technique is widely used: firstly, it greatly compresses the image for limitation of storage, secondly it reduces the amount of information for transmission over the network and lastly it removes redundant information that can be very useful in pattern recognition.

Generally image compression techniques are classified into two categories such as lossy and lossless compression. Lossless compression techniques are used to compress the images without changing any quality or content. Lossless techniques can be used for medical imaging, technical drawings, etc. Lossy techniques provide compression even at tolerable degradation in quality or content. Lossy compression techniques can be used for natural images.

JPEG (Joint Photographic Experts Group) standard developed image compression technique named as JPEG image compression which is a lossy type compression.JPEG compression can be used for images where there is a gradual change in their properties such as color, tonal values, etc. JPEG can be used for still images only. JPEG image compression basically uses a technique known as DCT.

DCT (Discrete Cosine Transform) is mainly used for converting spatial components into frequency components in frequency domain. DCT is a robust method in image compression which is used to compact or reduce highly related data.DCT increases information packing ability and reduces the computational complexity.
Procedure for Paper Submission

II. LITERATURE SURVEY

The implementation of 2D-DCT along with quantization and zigzag scan represented in a pipelined architecture in [1].The design of lossy compression algorithm for color images using JPEG compression in [2]. Software algorithm has been developed and implemented to compress and decompress the given image using Huffman coding techniques in a MATLAB platform in [3].A simple entropy encoder algorithm is proposed and implemented which works on quantized coefficients of the discrete cosine transform in [4]. An image compression algorithm was comprehended using Matlab code, and modified to perform better when implemented in hardware description language. The IMAP block and IMAQ block of MATLAB was used to analyse and study the results of Image Compression using DCT and varying coefficients for compression were developed to show the resulting image and error image from the original images in [5].

The objective is to carry out the performance analysis of JPEG on the basis of quantization tables [6]. The Nelson algorithm had been used for the generation of quantization table[6]; and an attempt has been made for the identification of the best quantization table, because for digital image processing (DIP), it is necessary to discover a new quantization tables to achieve better image quality than the obtained by the JPEG standard in [6]. A stereo image is produced by taking two cameras, and recording the perspectives of the right eye and the left eye using different lenses in [7]. The left image is taken as the reference image and the disparity vectors between the two images are estimated using the Block Matching Algorithm [7]. The reference image is transformed using two-dimensional discrete cosine transform (DCT-II) and quantized using the quantization matrix. The resulting matrix is compressed into a bit stream using arithmetic coding in [7].

A listless implementation of wavelet based block tree coding (WBTC –Wavelet Based Truncation Coding) algorithm of varying root block sizes. WBTC algorithm improves the image compression performance of set partitioning in hierarchical trees at lower rates by efficiently encoding both inter and intra scale correlation using block trees [8]. The coding technique used approximate matching technique along with the concept of run length to encode the image data into a stream of integer data in [9]. A method for the compression of medical images using hybrid compression technique (DWT, DCT and Huffman coding been proposed). The objective of this hybrid scheme is to achieve higher compression rates by first applying DWT and DCT on individual components RGB in [10].

III. RELATED WORK

Original image is divided into blocks of 8 x 8.Pixel values of a black and white image range from 0-255 but DCT is designed to work on pixel values ranging from -128 to 127 .Therefore each block is modified to work in the range. DCT matrix is calculated by equation (3.1). DCT is applied to each block by multiplying the modified block with DCT matrix on the left and transpose of DCT matrix on its right.

The DCT transforms the data from the spatial domain to the frequency domain. The spatial domain shows the amplitude of the color. The frequency domain shows how quickly the amplitude of the color is changing from one pixel to the next in an image file. DCT is applied to each block by multiplying the modified block with DCT matrix on the left and transpose of DCT matrix on its right.DCT matrix is calculated by,

$$F(u,v)\frac{1}{4}C(u)C(v)\left[\sum_{x=0}^{7}\sum_{y=0}^{7}f(x,y).\cos\left(\frac{(2x+1)u\pi}{16}\right).\cos\left(\frac{(2y+1)v\pi}{16}\right)\right]$$

Where, $C_u = \frac{1}{\sqrt{2}}$ *for u* = 0, C_u = 0 *otherwise*

Cv = $\frac{1}{\sqrt{2}}$ *for v* = 0 , C_v = 0 *otherwise*

Each block is then compressed through quantization using the quantization table. After quantization, most of the high frequency coefficients are zeros. To exploit the number of zeros, a zig-zag scan of the matrix is used yielding to long string of zeros.The following equation (4.1) describes the quantization of one 8x8 block after DCT.

$$F_{Quant}(u,v) = Round\left(\frac{F(u,v)}{Q(u,v)}\right)$$

where Q(u,v) is the quantization table.

Some types of existing scan patterns are: Raster Horizontal (RH) Scan**:** The image is scanned row by row from top to bottom and from left to right within each row. Raster Vertical (RV) Scan**:** The image is scanned column by column from left to right and top to bottom within each column.

Snake Horizontal (SH**)** Scan**:** This is a variant of the Raster Horizontal Scan method described above. In this method, the image is scanned row by row from top to bottom, and the rows are alternatively scanned from left to right and from right to left. Snake Vertical (SV) Scan**:** This is a variant of the Raster Vertical Scan method described above. In this method, the image is scanned column by column from left to right and top to bottom, and the columns are alternatively scanned from top to bottom and from bottom to top as shown in Figure.3.1.

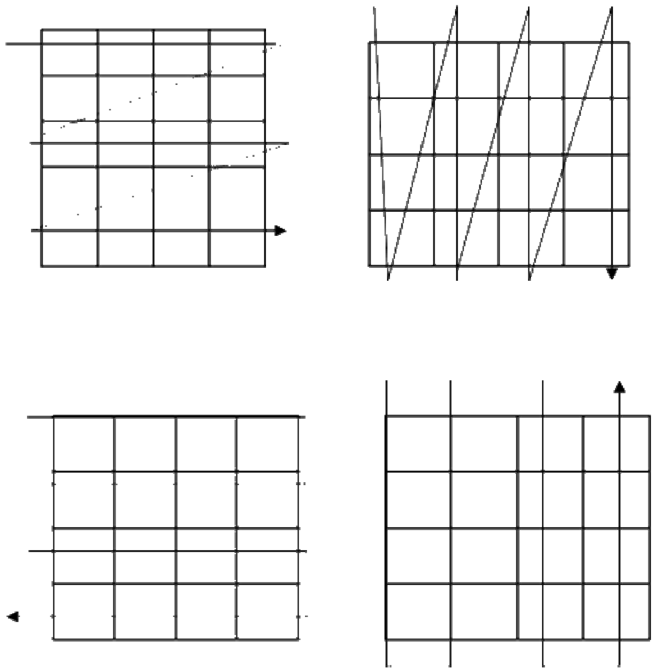

Figure 3.1 Raster Scanning Paths

Z - Horizontal Scan (ZH)**:** In this the image is scanned as a raster horizontal on a 2×2 block extending to cover the entire image. Z - Vertical Scan (ZV)**:** In this the image is scanned as a raster vertical on a 2×2 block extending to cover the entire image. Zig-zag Or Diagonal Scan (ZV)**:** The image is scanned along the anti-diagonals (i.e., line with constant row plus column value) beginning with the top-most anti-diagonal. Each anti-diagonal is scanned from the left bottom corner to the right top corner as shown in Figure.3.2.

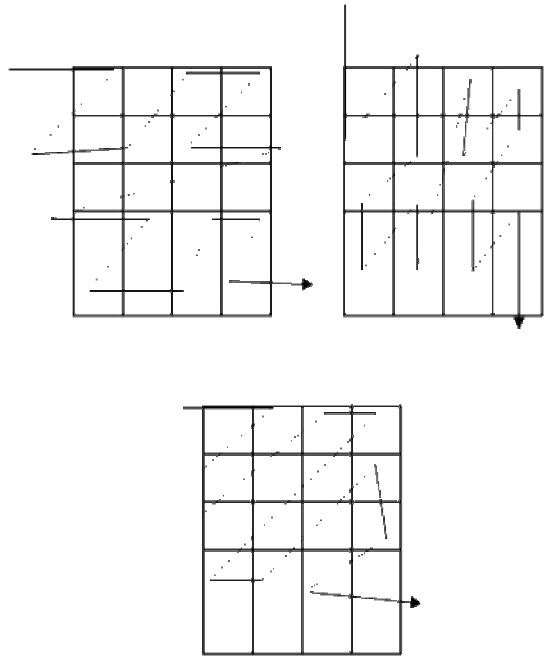

Figure 3.2 Z Scanning Paths

Spiral Scan: In this, the image is scanned from the outside to the inside, tracing out a spiral curve starting from the top left corner of the image and proceeding clockwise as shown in Figure.3.3. Cross Scan: In this the image is scanned using a cross on 3×3 block and the path is recursively applied over the entire image as shown in Figure.3.4.

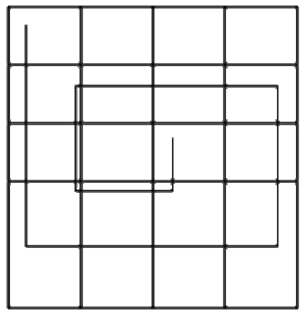

Figure 3.3: Spiral Scan

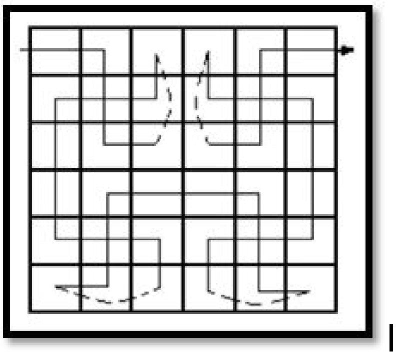

Figure 3.4 Cross Scan

PEANO-HILBERT SCAN: This scan method is due to Peano and Hilbert, and is best described recursively as in Figure 3.4. This method requires the image to be a $2^k \times 2^k$ image. When *k* is odd, the scan path starts at the leftmost pixel of the first row and ends at the leftmost pixel of the bottom row.

When *k* is even, the path starts at the leftmost pixel of the first row and end at the right-most pixel of this row. In a Peano-Hilbert scan, the image is scanned quadrant by quadrant. The scan path for a $2^k \times 2^k$ image for k = 1, 2, and 3 is shown in Figure 3.5.

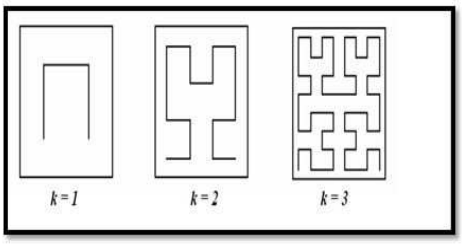

Figure 3.5 Peano-Hilbert scan at k=1, 2 and 3

The entropy coding is the final step of the JPEG compression. A pre-processing is needed before the entropy coding though. First the DC coefficients from the adjacent 8x8 blocks have a strong correlation. Their values are therefore most of the time very close and that is why it is more interesting to save only the difference between the DC terms in order to achieve further compression. This is called the Differential Pulse Code Modulation (DPCM), it follows the given equation :

$$DIFF = DC(N) - DC(N-1) \text{ with } N \geq 1,$$

$$DC(0) = 0$$

The output obtained after DPCM and zig-zag scanning is ready to be encoded using the Huffman coding method. 8x8 blocks (which are now 1x64 blocks) are encoded separately and the encoding is different for the DC coefficients and the AC coefficients. The entropy coding can be seen as two steps. The first one called the run-level coding (RLC) converts the zig-zag sequence into an intermediate sequence of symbols which will be converted into the final data stream of bits in the second step.

Now all the processes till encoding are reversed (i.e., Run length decoding, inverse zigzag scan, inverse quantization, inverse DCT) to obtain compressed image of same quality as the original image.

IV. PROPOSED WORK

The proposed architecture is shown in figure 4.1. The picture to be compressed is first padded in order to have its height and width multiple of 8. The value of the padded blocs is generally 255 (white) or 0 (black). After the padding, the image will be divided in blocks of 8 by 8.Each block will be treated separately. Now the divided blocks are used to extract RGB components. Then the extracted component values are used to apply DCT (Discrete Cosine Transform).The resulting matrix is used for quantization using the luminance quantization table used for JPEG compression. Now the quantized matrix is further applied through zigzag scan.

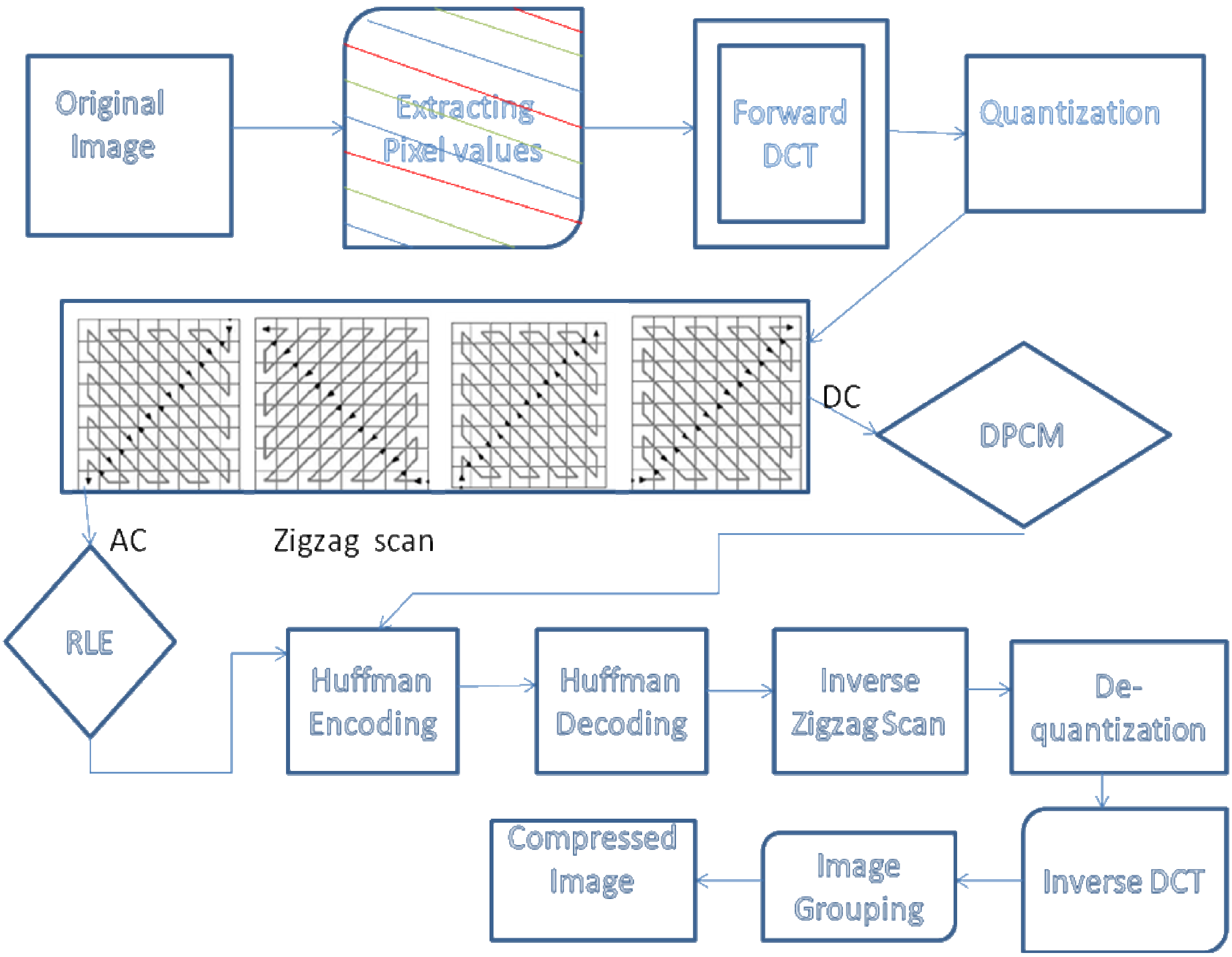

Figure: 4.1 Proposed Architecture

This paper proposes various zigzag scanning paths as shown in figure 4.2. The output from zigzag scan will be in single dimensional form. The scanned matrix is further used for separation of AC and DC components.

The DC component is the value of zigzag scan matrix where both column and row values are zero and all the remaining values are AC coefficients. Now the DC coefficients are encoded by DPCM (Differential Pulse Code Modulation) which is given by the difference between the value of the previous block and the current block.

The AC coefficients are encoded by RLE (Run Length Encoding) which is given or represented by the number of zeros obtained in each block. Now the encoded DC and AC values are further encoded by Huffman encoding table. The encode values are further applied to reverse processes such as decoding, inverse zigzag scan, inverse quantization, inverse DCT(Backward DCT), image grouping to yield the compressed image.

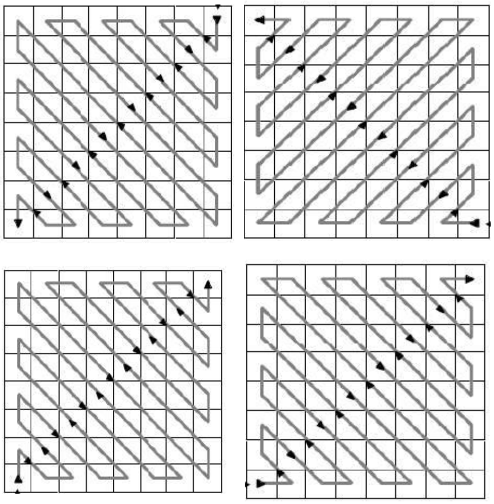

Figure4.2:Zigzag Scanning Paths(ZzRotateLeft90º, ZzRotateRight90º, ZzRotate180º, ZzVertical)

C) ZzRotate180:

Scan starts at (7, 7) then moves to the previous position. Now the row value gets decremented and column value gets incremented at the next scan. Again the scan moves to the decremented row but the same column. In the next scan column value gets decremented and row value gets incremented. Now the row value gets incremented and column value gets decremented. The scan now moves to the previous column but the same row. Now the scan path moves till the pointer reaches the starting row. This process continues till all values are visited.

D) ZzVertical:

Scan starts at (7, 0) and moves to the next position. Now the row and column value gets decremented. Again the scan moves to the decremented row but the same column. Now the scan moves to incremented row and column. Again the scan moves to the incremented row and column value. This process continues till all values are visited once.

A) ZzRotateRight90:

Scan starts at (0, 7) then moves to the next position. Now the row value and column value gets decremented at the next scan. Again the scan moves to the decremented column but the same row. In the next scan, column value and row value gets incremented. Now the row and column values again get incremented. The scan now moves to the next row but the same column. Now the scan path moves till the pointer reaches the starting row. This process continues till all values are visited.

V RESULTS AND ANALYSIS

Tabulation of results is carried out for 3 test images namely lena.jpeg, barbara.jpeg and couple.jpeg. Compression factor is the factor by which the quantization matrix is multiplied. The performance can be calculated by some measuring parameters CR, PSNR are measured. Compression factor decides the CR and hence the number of bits required to represent the compressed image.

Images	8:1	32:1	128:1
Barbara	47.85	41.12	39.34
Couple	48.76	41.77	40.57
Lena	42.93	42.28	41.79

Table: 5.1 Compression Ratio And PSNR

In the following figure 5.1, the X axis indicates the compression ratio and Y axis indicates PSNR. Compression algorithm for three different images for different compression factors is shown in figure 5.1.

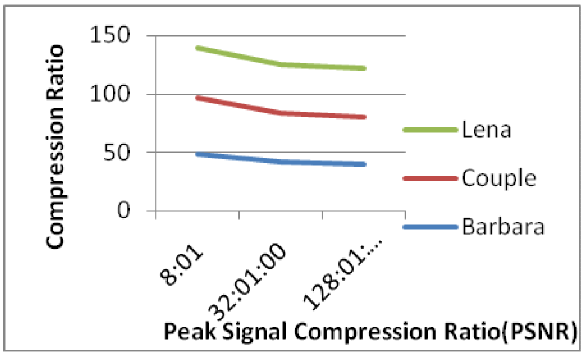

Figure: 5.1PSNR and Compression Ratio

For the different images even if the compression ratio remains same PSNR are found to be different. From these results it may be concluded that performance of JPEG will not remain same for the given compression factor & it changes from image to image. Compression ratio is given by,

$$Compression\ Ratio = \frac{Size\ of\ the\ original\ image}{Size\ of\ the\ compressed\ image}$$

The size of the original image is given by,

$$Size\ of\ the\ original\ image = height * width * 8$$

The second matric used for analysis in JPEG compression is PSNR(Peak Signal Noise Ratio) and is given by,

$$PSNR = 10\ \log 10 \frac{MAX_I^2}{MSE}$$

Where MSE is the Mean square error, defined as,

$$MSE = \frac{1}{h.w} \sum_{i=0}^{h-1} \sum_{j=0}^{w-1} (I(i,j) - K(i,j))^2$$

Where I stands for the original picture, K the compressed picture and h, w are the height and width of these pictures.

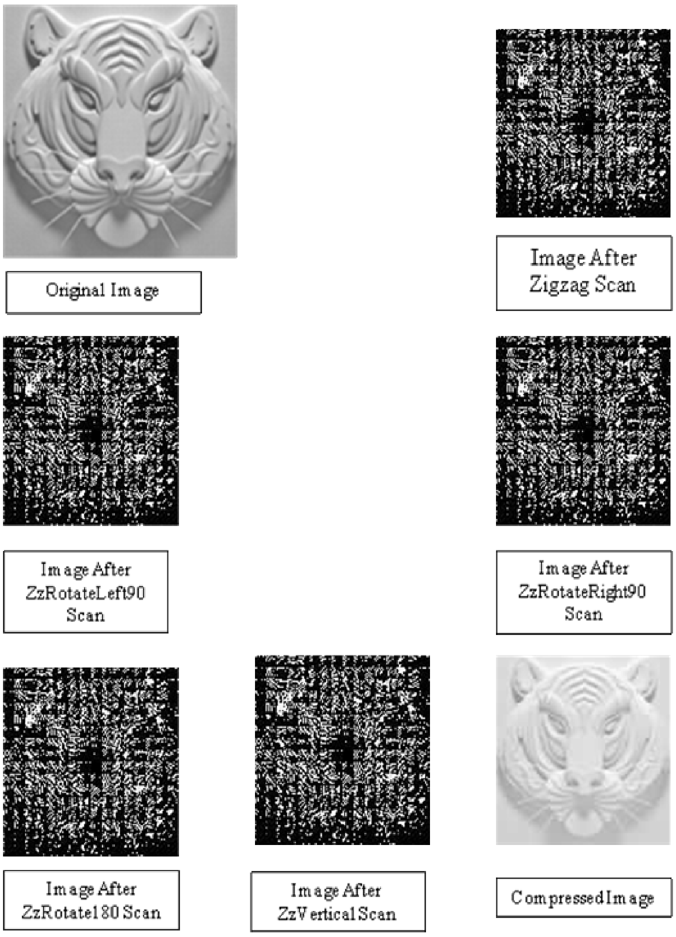

Figure: 5.2 Paper art image after applying various zigzag scan paths

The results for two images namely paper art and running foal after various types of zigzag scans are shown in figures 5.2, 5.3.The standard images Barbara and Lena gave better results for compression ratio and peak signal noise ratio.

The jpeg compression based on DCT is favourable for reducing the overall processing time and the jpeg data based on compression domain is greatly reduced as compared to the original data, so it is very useful for improving the efficiency of the system. Some of the compression algorithm, to a certain extent, meets the requirement of the analysis and processing of the jpeg image data.DCT Compression technique can be applied to different JPEG images and different types of results can be obtained.

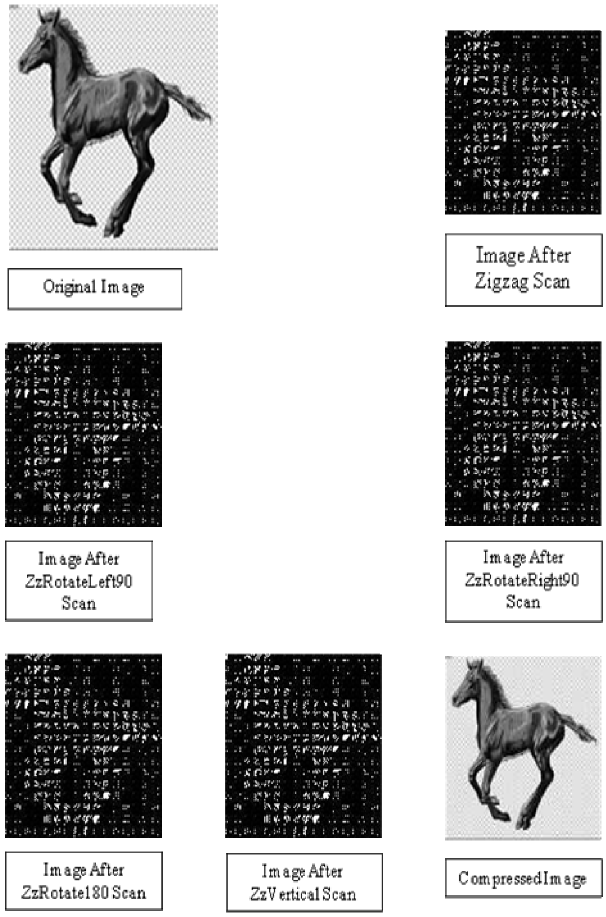

Figure: 5.3 Running foal image after applying various zigzag scan paths

V CONCLUSION

Image compression is an extremely important part of modern computing. By having the ability to compress images to a fraction of their original size, valuable and expensive disk space can be saved. In addition, transmission of pictures from a device to another becomes easier and takes less time. The JPEG image compression algorithm provides a very effective way to compress images with minimal loss in quality.

DCT is used for transformation in JPEG standard. DCT performs better in the context that it avoids blocking artifacts which degrade reconstructed images. The technique\ is particularly amenable to the design of relatively simple, fast decoders and it can be used as a key component in compression. Test images are introduced into quantization and zigzag scan process, which yields better results.

REFERENCES

1) K. Deepthi, R. Ramprakash, “Design and Implementation of JPEG Image Compression and Decompression”, International Journal of Innovations in Engineering and Technology, Vol.2, Issue 1, February 2013.
2) Fouzi Douak, Redha Benzid, Nabil Benoudjit, “Color image compression algorithm based on the DCT transform combined to an adaptive block scanning”, Int.J.Electron.Commun,2011.
3) Jagadish H. Pujar, Lohit M. Kadlaskar,“A new lossless method of image compression and decompression using huffman coding techniques”,Journal of Theoretical and Applied Information Technology,2010.
4) Malarvizhi D, Kuppusamy K,“A new entropy encoding algorithm for image compression using DCT”,International Journal of Engineering Trends and Technology-Volume3, Issue3, 2012.
5) Maneesha Gupta, Amit Kumar Garg, ”Analysis Of Image Compression Algorithm Using DCT”, International Journal of Engineering Research and Applications (IJERA), Vol. 2, Issue 1,pp.515-521, Jan-Feb 2012.
6) Mumtaz Ahmad Khan,Qamar Alam,Mohd Sadiq,“Performance Analysis of JPEG Algorithm on the Basis of Quantization Tables”, Proc. of Int. Conf. on Front. of Intell. Comput., Springer-Verlag Berlin Heidelberg 2013.
7) Ramaprabha, Mohamed Sathik M. , “An analytical study on stereo image compression using DCT II and vector quantization“, International Journal of Advanced Research in Computer Science and Software Engineering, Volume 2, Issue 1, January 2012.
8) Ranjan K. Senapati,Umesh C. Pati,Kamala Kanta Mahapatra,”Listless block-tree set partitioning algorithm for very low bit rate embedded image compression”,Int.J.Electron.Commun,2012.
9) Samir Kumar Bandyopadhyay, Tuhin Utsab Paul, Avishek Raychoudhury ,”Image Compression using Approximate Matching and Run Length“,International Journal of Advanced Computer Science and Applications, Vol. 2, No. 6, 2011.
10) Sandhya Sharma, Sarabjeet Kaur,“Image Compression using hybrid of DWT,DCT and Huffman Coding”, International Journal for Science and Emerging Technologies with Latest Trends,2013.