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Performance Evaluation of Relation between Image Compression and Quality Factor in case of JPEG Image Compression

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Abstract: Advances over the past decade in many aspects of digital technology - especially devices for image acquisition, data storage, and bitmapped printing and display - have brought about many applications of digital imaging. However, these applications tend to be specialized due to their relatively high cost. Use of digital images often is not viable due to high storage or transmission costs, even when image capture and display devices are quite affordable. JPEG is the most frequently applied/used image compression technique in today's world. This paper presents an efficient image compression approach based on JPEG image compression. We have developed an application based on VB.NET for converting and compressing images in JPEG format. Using this application we finally propose a relation between image quality with the amount of image compression.

***Keywords**:* Compression, Peak signal-to-noise ratio, Discrete Cosine Transform, Quantization, Encoding.

I. INTRODUCTION

Our requirements may outstrip the anticipated increase of storage space and bandwidth. The bit rate of digital data may exceed 1 GBPS, so we require compression. With the possible exception of facsimile, digital images are not common place in general-purpose computing systems the way text and geometric graphics are. The majority of modern business and consumer usage of photographs and other types of images takes place through more traditional analog means. The key obstacle for many applications is the vast amount of data required to represent a digital image directly. A digitized version of a single, color picture at TV resolution contains on the order of one million bytes; a 35mm resolution requires ten times that amount. Modern image compression technology offers a possible solution. State-of-the-art techniques can compress typical images from 1/10 to 1/50 their uncompressed size without visibly affecting image quality[1].

Compression means to reduce the volume of information or to reduce the bandwidth. The information can be text, image, speech, audio, video etc. Image compression means minimizing the size in bytes of a graphics file without degrading the quality of the image to an unacceptable level. The reduction in file size allows more image to be stored in a given amount of disk more memory space. It also reduces the time required for image to be sent over the internet or downloaded from web pages[2]. For this we have various compression algorithm that can be either 'lossless' or 'lossy'. In lossless compression algorithm we get exact copy of source information after decompression .So, it is reversible in nature. Lossless data compression schemes often consist of two distinct and independent components: modelling and coding. The modelling part can be formulated as an inductive inference problem, in which the data (e.g., an image) is observed sample by sample in some predefined order (e.g., raster-scan, which will be the assumed order for images in the sequel). The conceptual separation between the modelling and coding operations was made possible by the invention of the arithmetic codes , which can realize any probability assignment , dictated by the model to a preset precision[3][4]. In lossy, we do not get the exact copy of source information after decompression. Images can be either graphical images or digitized images. In either case we need compression. The main aim in image compression is the reduction of image data while preserving image details. There are many compression algorithm which compresses images in various format such as GIF (Graphical Interchange Format), TIFF (Tagged Image File Format) , bitmap, JPEG etc. One of the latest topics in image compression today is JPEG. The acronym JPEG means Joint Photographic Experts Group. It is a standard committee that has its roots in international organisation for standardization (ISO). Firstly, ISO in 1982 formed the PEG whose main aim was to produce a set of standards for transmission of images and graphics over communication network[5]. In 1986 CCIT gave method for compressing colour and gray scale data for facsimile transmission. These methods were found very similar to those being researched by PEG. Later in 1987 , ISO and CCIT joined hands and produced a single standard of image data compression called as JPEG[6].

JPEG compression is based on psycho-visual studies of human perception. To convert to a smaller file size, this type of compression drops the least- noticeable picture information. Human visual system response is dependent on the spatial frequency. JPEG is a lossy image compression algorithm that uses Discrete Cosine Transform (DCT). DCT provides a good approximation to allow one to decompose an image into a set of waveforms, each with a particular spatial frequency. This allows us to successively drop frequency components that are imperceptible to the human eye. JPEG is better than other compression formats in many ways. For example,

a. It works best with photographs and complex Images. It uses a compression method that removes non human visible colours from images to decrease file sizes.
b. JPEG stores images with pixel depth between 6 to 24 bits with reasonable speed and efficiency.
c. JPEG is a lossy method of compression. It removes useless data away during encoding. So, JPEG has better and superior compression ratio over most lossless schemes.

The various steps in the JPEG compression are[7]:

a) Block Preparation:- In pixel form, the image is made up of one or more 2D matrices of values. In this step, the total matrix is divided into a set of smaller 8X8 sub matrices each of which is known as block.

b) Forward DCT:- In this step a Discrete Cosine transform(DCT) is applied to each block of pixel, thus removing redundant image data.

DCT is computed as,

$$F[i,j] = \frac{1}{4}\ c(i)\ c(j) \sum_{x=0}^{7} \sum_{y=0}^{7} P[x,y] \cos[(2x+1)i\pi]/16 \ .\ \cos[(2y+1)j\pi]/16$$

Where,

$c(i)$ and $c(j) = 1/\sqrt{2}$ for i,j=0

=1 for all other values of i and j and x, y, i and j all vary from 0 to 7.

c) Quantization:- Quantize each block of DCT coefficient using weighting function optimized for the human eye.

d) Encoding:- Encode the resulting data using a Huffman variable word length algorithm to remove redundancies in the coefficients.

The block diagram for JPEG compression algorithm is shown in figure 1.

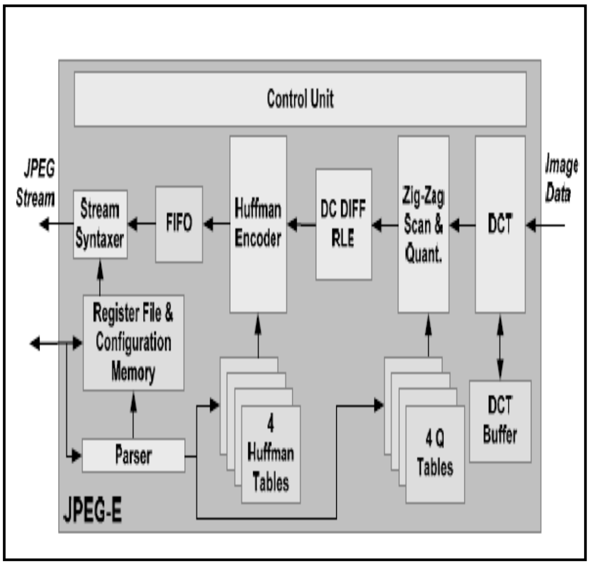

Figure 1: Block Diagram of JPEG Compression

In order to determine if the JPEG compression metric forms an effective transcoding, we need the ability to measure the JPEG Quality Factor of an image. Without the ability to measure the initial Quality Factor used to produce an image, the transcoding algorithm might transcode an image with a low initial Quality Factor to an apparently higher Quality Factor value by manipulating the quantization tables, even though such an operation does not increase the information quality of the output transcoded image. The resulting output image from such an operation is bigger than the original “lower quality” image.

II. PROPROSED METHOD

In recent years, there has been an increasing need to develop objective measurement techniques that can predict image/video quality automatically. Such methods can have various applications. First, they can be used to monitor image/video quality for quality control systems. Second, they can be employed to benchmark image/video processing systems and algorithms. Third, they can also be embedded into image/video processing systems to optimize algorithms and parameter settings. The most widely used objective image quality/distortion metrics are Peak Signal-to-Nose Ratio (PSNR) and Mean Squared Error (MSE), but they are widely criticized as well for not correlating well with perceived quality measurement. In the past three to four decades a great deal of effort has been made to develop new objective image/video quality metrics that incorporate perceptual quality measures by considering Human Visual System (HVS) characteristics Most of the proposed image quality assessment approach require the original image as a reference. Interestingly, human observers can easily assess the quality of distorted images without using any reference image[8].

We have developed an application based on VB.NET that follows JPEG compression method. It not only compresses images but also converts image of any format into JPEG image format. Our main aim is to show the relation between image quality with amount of compression. Image quality is the measure of how accurately our image matches the source image. It is observed by visible factors like brightness and evenness of illumination, contrast, resolution, geometry, colour fidelity and colour discrimination of an observed image. Although there are not any standardized quantization Matrices , most implementations of JPEG compression use a set of quantization matrices indexed by a quality factor from the set {1, 2, . . . , 100}. Theses matrices are used in the reference implementation provided by the Independent JPEG Group. We refer to them as standard matrices[9].

Generally as the amount of compression increases, quality decreases. In our application , we have specifically used JPEG because it can be adjusted to produce very small compressed image but they are relatively poor quality in appearance . Even those are suitable for many applications. The amount of compression achieved depends upon the content of image data. For smaller images even at very large compression ratio, we don’t experience any noticeable degradation in image quality. But as size of image increases, the degradation of quality is quite noticeable at large compression. The optimal value of compression ratio for an image having good quality varies as per size of original image. In our application, we can “tune” the quality of the JPEG image using the parameter called a Q factor. It vary from range between 1to 100. A factor 1 produces the image with maximum compression (i.e smallest) but with worst quality .The factor of 100 produces the image with least compression (i.e largest) but best quality. The optimal Q factor depends on the content of image and varies as per the size of image. Our main aim is to find the lowest Q factor that produces an image that is visibly acceptable and has good amount of compression also.

The screenshot of application we have developed (VB.NET) is shown in figure 2:

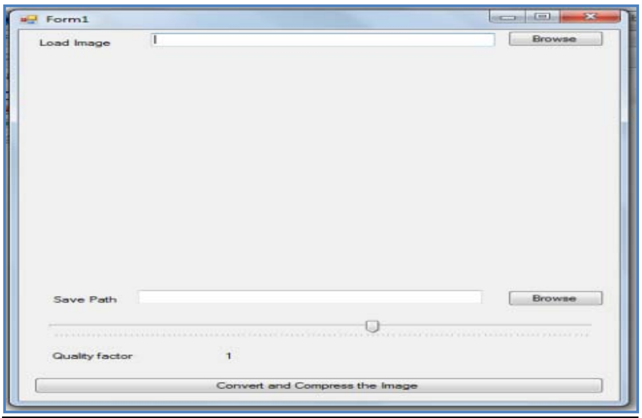

Figure 2: Screenshot of Application

III. EXPERIMENTAL RESULTS

To find the optimal compression we have applied our application on various images with size varying from 3 to 5 MB.

For image shown in figure 3 , the following results are obtained, shown below in figure 4, figure 5, figure 6 for various values of Quality factor=1, 30, 90 respectively.

Figure 3 : Original Image

Figure 4 : Image at Q-Factor 1

Figure 5 : Image at Q-Factor 30

Figure 6 : Image at Q-Factor 90

The graph shown in figure 7 shows variation of size of original image (figure 3) against Q- factor.

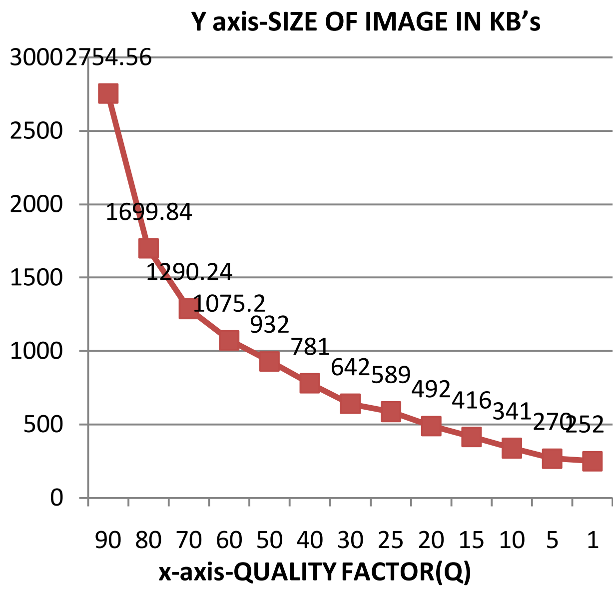

Figure 7-Graph between Quality actor (Q)and Size of Image (in kb's) for Image shown in Figure 3

IV. CONCLUSION

From the experimental results we conclude that for images of size between 3 to 5 MB, the optimal results are found at Q factor ranging from 25 to 30 where 80 to 85 percent compression can be obtained.

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