



Survey on JPEG Image Compression

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Abstract— Image compression is to reduce irrelevance and redundancy of the image data in order to be able to store or transmit data in an efficient form. Image compression is 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 images to be stored in a given amount of disk or memory space. It also reduces the time required for images to be sent over the Internet or downloaded from Web pages. There are several different ways in which image files can be compressed. This paper presents the performance of different block based discrete cosine transform (DCT) algorithms for compressing color image. In this work, we present a technique for disguising an image's JPEG compression history. An image's JPEG compression history can be used to provide evidence of image manipulation, supply information about the camera used to generate an image, and identify forged regions within an image. One image processing operation of particular forensic significance is JPEG compression, which is one of the most popular image compression formats in use today.

Keywords— Image Compression, DCT, JPEG Compression, Anti-Forensic

I. INTRODUCTION

Images are very important documents nowadays [1], to work with them in some applications they need to be compressed, more or less depending on the purpose of the application. Image compression is an application of data compression that encodes the original image with few bits. The objective of image compression is to reduce the redundancy of the image and to store or transmit data in an efficient form [2]. According to scientific revolution in the internet and the expansion of multimedia applications, the requirements of new technologies have been grown. Recently, many different techniques have been developed to address these requirements for both lossy and lossless compression [3][4]. With lossless compression, the ability to reconstruct the original image after compression is exact. It is rare to obtain error-free compression more than 2:1 ratio. On the other hand, in lossy compression [5] the ratio can be obtained with some error between the original image and the reconstructed image. In many cases, error-free reconstruction of the original image may be impossible. If the image has some noise, then there are denoising methods that can be used to reduce that noise. Therefore, lossy compression may produce an acceptable error that does not affect too much to the original image. There are some algorithms that perform this compression in different ways; some are lossless [1] and keep the same information as the original image, some others loss information when compressing the image. Some of these compression methods are designed for specific kinds of images, so they will not be so good for other kinds of images. Figure 1 shows the simple compression process of image

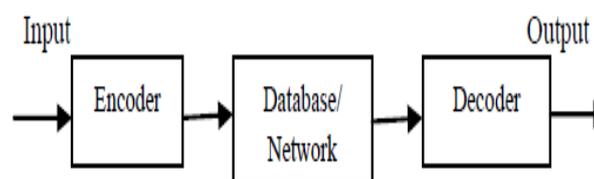


Fig 1: Simple Compression Technique.

II. IMAGE COMPRESSION TECHNIQUE

The objective of an image compression technique is to represent an image with smaller number of bits without introducing appreciable degradation of visual quality of decompressed image [6]. These two goals are mutually conflict in nature. In a digital true color image, each color component that is R, G, B components, each contains 8 bits data [7]. Also color image usually contains a lot of data redundancy and requires a large amount of storage space. In order to lower the transmission and storage cost, image compression is desired [8]. Most color images are recorded in RGB model, which is the most well known color model. However, RGB model is not suited for image processing purpose. For compression, a luminance-chrominance representation is considered superior to the RGB representation. Therefore, RGB images are transformed to one of the luminance-chrominance models, performing the compression process, and then transform back to RGB model because displays are most often provided output image with direct RGB model. The luminance component represents the intensity of the image and look likes a gray scale version. The chrominance components represent the color information in the image [9,10].

A. JPEG

In their FRVT 2000 Evaluation Report, Blackburn et al. tried to evaluate the effects of JPEG compression on face recognition [12]. They simulated a hypothetical real life scenario: images of persons known to the system (the gallery) were taken in near-ideal conditions and were uncompressed; unknown images (the probe set) were taken in uncontrolled conditions and were compressed at a certain compression level. Prior to experimenting, the compressed images were uncompressed (thus, returning to pixel domain), introducing compression artifacts that degrade image quality. They used standard gallery set (fa) and probe set (dup1) of the FERET database for their experiments. The images were compressed to 0.8, 0.4, 0.25 and 0.2 bpp [11]. The authors conclude that compression does not affect face recognition accuracy significantly. More significant performance drops were noted only under 0.2 bpp. The authors claim that there is a slight increase of accuracy at some compression ratios and that they recommend further exploration of the effects that compression has on face recognition. Moon and Phillips evaluate the effects of JPEG and wavelet-based compression on face recognition [13]. The wavelet-based compression used is only marginally related to JPEG2000. Images used as probes and as gallery in the experiment were compressed to 0.5 bpp, decompressed and then geometrically normalized. System was trained on uncompressed (original) images. Recognition method used was PCA with L1 as a nearest neighbor metric. Since they use FERET database, again standard gallery set (fa) was used against two also standard probe sets (fb and dup1). They noticed no performance drop for JPEG compression, and a slight improvement of results for wavelet-based compression. Wat and Srinivasan [14] explored the effects of JPEG compression on PCA and LDA with the same setup as in [12] (FERET database, compressed probes, uncompressed gallery). Results were presented as a function of JPEG quality factor and are therefore very hard to interpret (the same quality factor will result in a different compression ratios for different images, dependent on the given image's statistical properties). By using two different histogram equalization techniques as a preprocessing, they claim that there is a slight increase in performance with the increase in compression ratio for LDA in the illumination task (fc probe set). For all other combinations, the results remain the same or decrease with higher compressions. This is in slight contradiction with results obtained in [12].

B. History Of JPEG

In the late 1980's and early 1990's, a joint committee [15], known as the Joint Photographic Experts Group (JPEG), of the International Standards Organization (ISO) and the Comité Consultatif International Téléphonique et Télégraphique (CCITT) developed and established the first international compression standard for continuous-tone images. A good summary of their work can be found in [16]. The standard they produced [17] has since become ubiquitous on the Internet in the field of digital photography. It has also been extended and adapted for use in the encoding and compression of digital videos.

C. JPEG COMPRESSION USING DCT

1). JPEG Compression:

Components of Image Compression (JPEG) System. Image compression system consists of three closely connected components namely (Source encoder (DCT based), Quantizer and Entropy encoder). Figure 4(a) shows the architecture of the JPEG encoder [6].

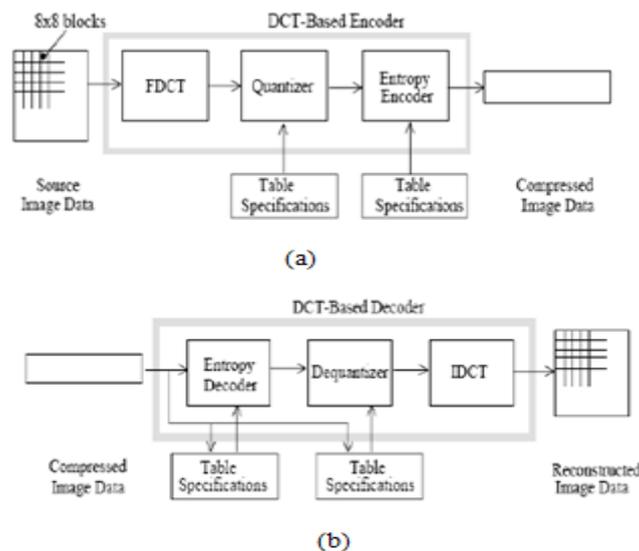


Figure 1: Typical image coding system (JPEG encoder/decoder), a) Block diagram of JPEG encoder processing steps, b) Block diagram of JPEG decoder.

A principle behind JPEG Compression, a common characteristic of most images is that the neighboring pixels are correlated and therefore contain redundant information. The foremost task then is to find less correlated representation of the image. Two fundamental components of compression are redundancy and irrelevancy reduction. Redundancy reduction aims at removing duplication from the signal source. Irrelevancy reduction omits parts of the signal that will not be noticed by the signal receiver, namely the Human Visual System (HVS). The JPEG compression standard (DCT

based) employs the use of the discrete cosine transform, which is applied to each 8x8 block of the partitioned image. Compression is then achieved by performing quantization of each of those 8x8 coefficient blocks. Image transform coding for JPEG compression algorithm. In the image compression algorithm, the input image is divided into 8-by-8 or 16-by-16 non-overlapping blocks, and the two dimensional DCT is computed for each block. The DCT coefficients are then quantized, coded, and transmitted. The JPEG receiver (or JPEG file reader) decodes the quantized DCT coefficients, computes the inverse two-dimensional DCT of each block, and then puts the blocks back together into a single image. For typical images, many of the DCT coefficients have values close to zero; these coefficients can be discarded without seriously affecting the quality of the reconstructed image. A two dimensional DCT of an N by N matrix pixel is defined as follows [6]:

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

$$\text{Where } C(x) = \begin{cases} \frac{1}{\sqrt{2}} & \text{if } x = 0 \\ 1 & \text{otherwise} \end{cases}$$

For decoding purpose there is an inverse DCT (IDCT):

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

The DCT based encoder can be thought of as essentially compression of a stream of 8x8 blocks of image samples. Each 8 X 8 block makes its way through each processing step, and yields output in compressed form into the data stream. Because adjacent image pixels are highly correlated, the forward DCT (FDCT) processing step lays the foundation for achieving data compression by concentrating most of the signal in the lower spatial frequencies. For a typical 8x8 sample block from a typical source image, most of the spatial frequencies have zero or near-zero amplitude and need not be encoded. In principle, the DCT introduces no loss to the source image samples; it merely transforms them to a domain in which they can be more efficiently encoded. After output from the FDCT, each of the 64 DCT coefficients is uniformly quantized in conjunction with a carefully designed 64–element quantization table (QT). At the decoder, the quantized values are multiplied by the corresponding QT elements to recover the original unquantized values. After quantization, all of the quantized coefficients are ordered into the “zig-zag” sequence [6].

This ordering helps to facilitate entropy encoding by placing low-frequency non-zero coefficients before high-frequency coefficients. The DC coefficient, which contains a significant fraction of the total image energy, is differentially encoded. Figure 4 (b) show the JPEG decoder architecture, which is the reverse procedure described for compression [6].

D. JPEG IMAGE ANTI-FORENSICS

In the JPEG standard, the input image is divided into B non-overlapping blocks of size 8×8 . For each block, the two-dimensional DCT transform is computed. Each transform coefficient X_i^b , $1 \leq b \leq B$, $1 \leq i \leq 64$, is then quantized using a uniform quantizer, with quantization step size q_i which depends only on the DCT subband [18]. The set of q_i 's forms the quantization matrix Q. While Q is not standardized, it is customary in many JPEG implementations to define Q as a scaled version of a template matrix Q_t , by changing a (scalar) quality factor Q. The quantization levels W_i^b are obtained from the original coefficients X_i^b as $W_i^b = \text{round}(X_i^b / q_i)$, and then entropy coded and written in the JPEG bitstream. When the bitstream is decoded, the DCT values are reconstructed from the quantization levels as $\hat{X}_i^b = W_i^b$. Then, the inverse DCT is applied to each block, and the result is rounded. and truncated in order to take integer values in the [0; 255] range. The distribution of the unquantized AC DCT coefficient is typically Laplacian. However, after dequantization, the reconstructed values \hat{X}_i^b can only be integer multiples of the quantization step size q_i . As a result, the distribution of the transform coefficients in a certain DCT subband will be composed by a train of spikes spaced apart by q_i . This comb-like structure reveals that: a) a quantization process has occurred; and, b) which was the original quantization step size. The anti-forensic technique in [19] thwarts the detection of JPEG compression by injecting a noise-like dithering signal into the dequantized DCT coefficients. The distribution of the dithering signal is designed in order to remove the traces left by the quantization process and to reconstruct the original coefficient distribution, i.e. a Laplacian distribution for AC coefficients, and an approximately uniform distribution for DC coefficients. The energy of the dithering signal necessary to restore the original DCT coefficient distribution depends on the initial JPEG quality factor Q, as well as on the image content. Generally speaking, this energy is higher for low quality factors and highly textured images [20]. In the spatial domain, this anti-forensic method introduces noise-like artifacts to the JPEG compressed picture.

III. CONCLUSIONS

Recently, a number of digital image forensic techniques have been developed which are capable of identifying an image's origin, tracing its processing history, and detecting image forgeries. Though these techniques are capable of identifying standard image manipulations, they do not address the possibility that anti-forensic operations may be designed and used to hide evidence of image tampering. In this paper, we survey on the concept of DCT and how it is implement in JPEG images and also explain the working of an anti-forensic operation capable of removing blocking from a previously JPEG compressed image.

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