"JPEG Image Compression Standard"

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Abstract

A joint ISO/CCITT committee known as JPEG (Joint Photographic Experts Group) standard for continuous-tone still images, both grayscale and color. Image compression is a widely addressed researched area. Still Image Compression is an important issue in Internet, mobile communication, digital library, digital photography, multimedia, and many other applications. A DCT-based method is specified for "lossy'' compression, and a predictive method for "lossless'' compression. JPEG features a simple lossy technique known as the Baseline method, a subset of the other DCT-based modes of operation. Image compression attempts to reduce the number of bits required to digitally represent an image while maintaining its perceived visual quality. JPEG compression can be applied to movies as well; it is simply done one frame at a time.

Keyword: Image compression, Jpeg, DCT

INTRODUCTION

Compressing an image is significantly different than compressing raw binary data. General purpose compression programs can be used to compress images, but the result is less than optimal. Uncompressed multimedia (graphics, audio and video) data requires considerable storage capacity and transmission bandwidth. Space. Lossy compression techniques save little more bandwidth or storage space. Image compression technique reduces redundancy in image data in order to store or transmit only a minimal number of samples from which a good approximation of the original image can be reconstructed in accordance with human visual perception. Data depends on information and computers continue to grow, so it does our need for efficient ways of storing and transmitting large amounts of data. JPEG compression is used with .jpg and can be embedded in .tiff and .eps files.JPEG Used on 24-bit color files and Works well on photographic images. Although it is a lossy compression technique, it yields an excellent quality image with high compression rates.

Principles of Compression

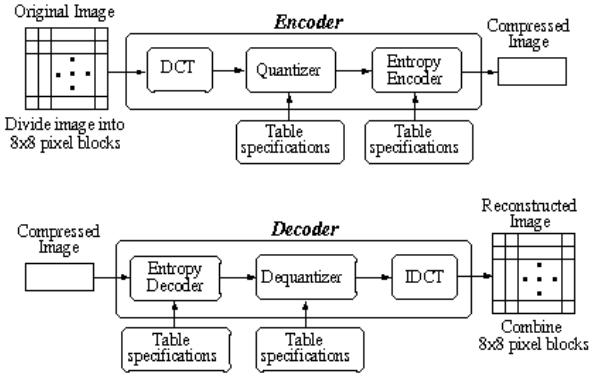
The goal of image compression is to reduce the amount of data required to represent a digital image. JPEG is capable of producing high quality compressed image. In image compression, if each pixel value represents a unique and perceptually important piece of information, it would be difficult indeed to compress an image. Fortunately, the data comprising a digital sequence of images are often redundant and/or irrelevant. Redundancy relates to the statistical properties of images, while irrelevancy relates to the observer viewing an image.

(a)Original image 83261bytes (b)decoded image 15138 Bytes

Example of image compression using JPEG standard

There is an example using JPEG image compression standard. The compression ratio is 15138/832610,about 0.1818, around one fifth of the original size. we can see that the decoded image and the original image are only slightly different. In fact, the two images are not completely same, that is, parts of information are lost during the image compression process

JPEG encoding and decoding



Steps in JPEG Compression

1.(Optionally) If the color is represented in RGB mode, translate it to YUV.
2. Divide the file into 8 X 8 blocks.
3. Transform the pixel information from the spatial domain to the frequency domain with the Discrete Cosine Transform
4. Quantize the resulting values by dividing each coefficient by an integer value and rounding off to the nearest integer.
5. Look at the resulting coefficients in a zigzag order.

Step 1: Converting RGB to YUV

- YUV color mode stores color in terms of its luminance (brightness) and chrominance (hue).
- The human eye is less sensitive to chrominance than luminance.
- YUV is not required for JPEG compression, but it gives a better compression rate.

RGB vs. YUV

- It's simple arithmetic to convert RGB to YUV. The formula is based on the relative contributions that red, green, and blue make to the luminance and chrominance factors.
- There are several different formulas in use depending on the target monitor. For example:

$$Y = 0.299 * R + 0.587 * G + 0.114 * B$$
$$U = -0.1687 * R – 0.3313* G + 0.5 * B + 128$$
$$V = 0.5 * R – 0.4187 * G – 0.813 * B + 128$$

Step 2: Divide into 8 X 8 blocks

- Note that with YUV color, you have 16 pixels of information in each block for the Y component (though only 8 in each direction for the U and V components).
- If the file doesn't divide evenly into 8 X 8 blocks, extra pixels are added to the end and discarded after the compression.
- The values are shifted "left" by subtracting 128.

Step 3: DCT

- The frequency domain is a better representation for the data because it makes it possible for you to separate out – and throw away – information that isn't very important to human perception.
- The human eye is not very sensitive to high frequency changes – especially in photographic images, so the high frequency data can, to some extent, be discarded.

For an N X N pixel image the DCT is an array of coefficients

$$[p_{uv}, 0 \le u < N, 0 \le v < N]$$

$$[DCT_{uv}, 0 \le u < N, 0 \le v < N]$$

$$DCT_{uv} = \frac{1}{\sqrt{2N}} C_u C_v \sum_{x=0}^{N-1} \sum_{y=0}^{N-1} p_{xy} \cos\left[\frac{(2x+1)u\pi}{2N}\right] \cos\left[\frac{(2y+1)v\pi}{2N}\right]$$

$$C_u C_v = \frac{1}{\sqrt{2}} \text{ for } u, v = 0$$

$$C_u C_v = 1 \text{ otherwise}$$

Step 4: Quantize the Coefficients Computed by the DCT

- The DCT is lossless in that the reverse DCT will give you back exactly your initial information (ignoring the rounding error that results from using floating point numbers.)
- The values from the DCT are initially floating-point.
- They are changed to integers by quantization.

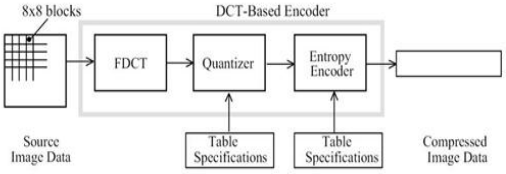


Figure 1. DCT-Based Encoder Processing Steps

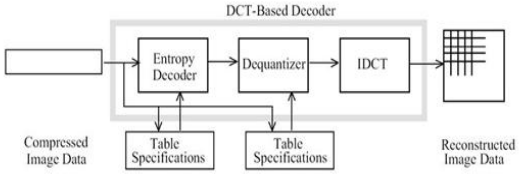


Figure 2. DCT-Based Decoder Processing Steps

Step 5: Arrange in "zigzag" order

- This is done so that the coefficients are in order of increasing frequency.
- The higher frequency coefficients are more likely to be 0 after quantization.
- This improves the compression of run-length encoding.
- Do run-length encoding and Huffman coding.

An Example of Image Compression–JPEG Standard

JPEG (Joint Photographic Experts Group) is an international compression standard for continuous-tone still image, both grayscale and color. This standard is designed to support a wide variety of applications for continuous-tone images. The JPEG standard has two basic compression methods. The DCT-based method is specified for lossy compression, and the predictive method is specified for lossless compression.

Run-Length Coding

The AC and DC components are treated differently. Since after quantization we have many 0 AC components, RLC is a good idea Note that most of the zero components are towards the lower right corner (high spatial frequencies) to take advantage of this, use Zig-Zag Scanning to create a 64-vector.

For example

- WWWWWWWWWWWWBWWW WWWWWWWWWWBBBWWWW WWWWWWWWWWWWWWW WWWWWBWWWWWWWWWWW WWWW If we apply the run-length encoding (RLE) data compression algorithm to the above hypothetical scan line, we get the following:
- 12W1B12W3B24W1B14W This is to be interpreted as twelve W's, one B, twelve W's, three B's, etc.

DC Coding and Zigzag Sequence

After quantization, the DC coefficient is treated separately from the 63 AC coefficients. The DC coefficient is a measure of the average value of the 64 image samples. Because there is usually strong correlation between the DC coefficients of adjacent 8x8 blocks, the quantized DC coefficient is encoded as the difference from the DC term of the previous block in the encoding order (defined in the following), as shown in Figure 3. This special treatment is worthwhile, as DC coefficients frequently contain a significant fraction of the total image energy. Finally, all of the quantized coefficients are ordered into the "zig-zag" sequence, also shown in Figure 3.This ordering helps to facilitate entropy coding by placing low-frequency coefficients (which are more likely to be nonzero) before high-frequency coefficients

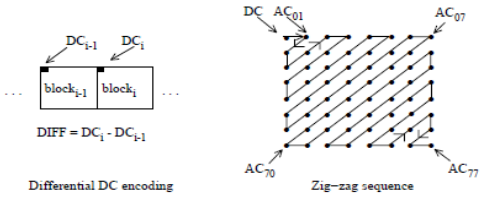


Figure 3. Preparation of Quantized Coefficients for Entropy Coding

Conclusions

We have introduced the basic concepts of image compression and the overview of JPEG standard. The JPEG standard has become the most popular image format. Fast and efficient lossy coding algorithms JPEG and JPEG2000 for image Compression/Decompression using Discrete Cosine and Fast Wavelet Transform are discussed with Huffman coding schemes. We have shown how JPEG compression is achieved and that it is effective in its goal of reducing file size while keeping quality. We have demonstrated that the compression algorithm utilizes the Discreet Cosine Transform to change the basis of the image matrix from the special basis to the frequency basis, and at the same time separate the low frequencies.

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