Compression Method in JPEG Standard

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Abstract. Data compression is to minimize the communication and storage. The bandwidth and storage required for a given communication system. Data compression is obviated by wideband technologies such as optical fiber communication networks, packet radio and optical storage disk. Images can generate data in such high volumes that any transmission media can be quickly overwhelmed. Personal computers and workstations has led to an increasing demand to store images in compressed from on magnetic or optical disks. The massive efforts taking place today to adopt national and international standards for signal compression. Example is the JPEG (Joint Photographic Experts Group) standard for image compression. Compression in the image from RGB in JPEG standard converted to YCbCr. Each Y, Cb, Cr divided in block 8x8 pixel. The image 8x8 pixel then transformed use DCT. Image from DCT quantized yield DC and AC component. DC component processed use DPCM (Differential Pulse Code Modulation) use Huffman table yield AC bit stream. Merge DC component and AC component yield JPEG bit stream. To get image from JPEG bit stream first use Huffman decoding. From Huffman decoding dequantized. Then transform use IDCT. Image from IDCT merge block 8x8 pixel. From block 8x8 pixel transformed YCbCr to RGB. Then get the image. Process compression is consist of lossy compression and lossless compression. Lossy compression is compression with change of data but not change meaning of information in there. Lossless compression is compression not to change data.

Keywords: JPEG, Lossy, Lossless, DCT, Quantization

1. Introduction
The aim of this work is to minimize byte the bandwidth and storage. The word signal refers to a continuous time and continuous amplitude waveform will view a signal in its more general sense as a function of time. Where time may be continuous or discrete and where the amplitude or values of the function may be continuous or discrete and may be scalar or vector-valued. Data viewed as a discrete time signal [1]. A signal may have a continuous or discrete amplitude. If the signal has both continuous time and continuous amplitude. It is called a continuous signal or an analog signal. If the signal has both discrete time and discrete amplitude say it is a discrete signal or digital signal or is data in the narrow sense. The ASCII code (American Standard Code for Information Interchange) for characters is a good example of discrete or digital data is a sequence.

Transforming the ASCII sequence into one of these alternative representations is an example of coding data. Signals must be communicated over a digital communication channel such as a modem or packet network or stored in a digital channel such as a standard computer memory. It may be however that either the original signal is analog or that it is digital but not in an appropriate form for...
the transmission or storage in the given channel example for octal data and a binary channel. The original signal must be coded or transformed into a form suitable for the channel. This general operation will be referred to as signal coding. The original signal must be transformed or coded into a form suitable for the channel. This general operation will be referred to as signal coding. Signal compression or data compression codes are used to reduce the amount of memory needed to store a message or to reduce the amount of bandwidth needed to transmit data [2]. Different data require different techniques to remove the redundancy and to identify the redundancy in the data. Data compression viewed as a means for efficient representation of a digital source of data such as image. Data compression is the process of converting an input data stream into another data stream that has a smaller size.

1. **Lossy Compression**

Lossy compression techniques involve some loss of information and data have been compressed using lossy techniques generally cannot be recovered or reconstructed exactly. When the compressed stream is decompressed then the result is not identical to the original data stream. Figure 1 shows an example where a long decimal number becomes a shorter approximation after the compression-decompression process [3, 4].

![Figure 1. Lossy compression algorithms (courtesy of Ida Mengyi Pu).](image)

1.2 **Lossless Compression**

If data have been losslessly compressed then the original data recovered exactly from the compressed data. For example in Figure 2. Lossless compression techniques are used when the original data of source are so important that cannot afford to lose any details.

![Figure 2. Lossless compression algorithms (courtesy of Ida Mengyi Pu).](image)

2. **Experimental method**

The experimental method compression in JPEG (Joint Photographic Experts Group) in figure 3.
2.1 Transformation RGB to YCbCr

The eye is very sensitive to small changes in luminance which is why it is useful to have color spaces that use Y as one of their three parameters. The luminance Y varies between 0 and 255 then will be renormalized between 16 the black threshold to 235. The chrominance presence or absence of blue (Cb) and red (Cr) varies between -127.5 and 127.5 but will be renormalized between 16 and 240 with 128 as zero value [5]. There are several YCbCr sampling formats such as 4:4:4, 4:2:2, 4:1:1 and 4:2:0 [6]. Transforming RGB to YCbCr is done by:

\[
Y = \frac{77}{256} R + \frac{150}{256} G + \frac{29}{256} B
\]

(1)

\[
Cb = \frac{-44}{256} R - \frac{87}{256} G + \frac{131}{256} B + 128
\]

(2)

\[
Cr = \frac{131}{256} R - \frac{110}{256} G + \frac{21}{256} B + 128
\]

(3)

While the opposite transformation is

\[
R = Y + 1.371(Cr - 128)
\]

(4)

\[
G = Y - 0.698(Cr - 128) - 0.336(Cb - 128)
\]

(5)

\[
B = Y + 1.732(Cb - 128)
\]

(6)

Figure 3. The experimental method compression in JPEG standard (courtesy of Author).

2.2 Block Pixel

The pixels of each color component are organized in groups of 8 x 8 pixels. If the number of image rows or columns is not a multiple of 8 then the bottom row and the rightmost column are duplicated as many times as necessary. Using ranges 8 x 8 pixels would achieve a good quality for the decoded image [7].

2.3 DCT and IDCT

The commonly used discrete cosine transform (DCT) is two dimensional and can be described by an 8x8 transform matrix as equation 7. The inverse DCT (IDCT) as equation (8) [8].
\[ G_{ij} = \frac{1}{4} C_i C_j \sum_{x=0}^{7} \sum_{y=0}^{7} \left( P_{xy} \cos \left( \frac{(2x + 1)i\pi}{16} \right) \cos \left( \frac{(2y + 1)j\pi}{16} \right) \right) \]

Where

\[ C_f = \frac{1}{\sqrt{2}} \text{ if } f = 0, \quad C_f = 1 \text{ if } f > 1 \]

and \(0 \leq i, j \leq 7\)  \hspace{1cm} (7)

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2.4 Quantization

The formula for quantization is

\[ \text{Quantized Value } (i, j) = \frac{DCT(i, j)}{Quantum(i, j)} \]  \hspace{1cm} (9)

During decoding then the dequantization formula operates in reverse.

\[ DCT(i, j) = \text{Quantized value } (i, j) \times Quantum(i, j) \]  \hspace{1cm} (10)

Errors generated in the high frequency components during dequantization normally don’t have a serious effect on picture quality [9].

2.5 Huffman Coding and Decoding

Encoding generalized to the lossy compression called differential encoding. For example DPCM (Differential Pulse Code Modulation). The Huffman coding deals with the 63 AC (Alternating Current) coefficients. The absolute values of which are in general sensibly smaller than the absolute value of the dominant DC (Direct Current) coefficient. The encoding concerns the sequence of the non-zero coefficient in the zigzag reading of the quantized scheme. Huffman coding conveniently begin with a hierarchy of 10 categories for the non-zero coefficients [10].

Non-zero coefficient occurring in the sequential reading of a quantized scheme can be characterized by three parameters that is the number of zeros which separate it from its non-zero predecessor, category and number within the category.
JPEG from the average statistics of a large set of images with 8 bit precision. Remark on two particular symbols that is end of block (EOB) indicates the end of the non-zero coefficients in the sequence of the 63 AC coefficients to be encoded. The code word will be 1010 and zero run list (ZRL) indicates the outcome of the integer 0 preceded by a block of 15 zeros [11-13].

Huffman decoding compressed file by sliding down the code tree for each symbol is simple. The compressed file has to be read bit by bit and the decoder has to advance a node in the code tree for each bit. The method of this section uses preset partial decoding table. These table depend on the Huffman code used but not on the data to be decoded. The compressed file is read in chunks of k bits each and the current chunk is used as a pointer to a table. The code word permits the reconstruction of the matrix of the quantized values. Dequantization means multiplication with the divisor scheme that has been used for quantization. The loss of information due to quantization becomes apparent. The decompression will be finished after transforming the matrix of dequantized values back and making the necessary rounds.

3. Results and discussion
Noise can change data image. Small or big noise result from difference between the pixel of the original image by \( P_i \) and the pixels of the reconstructed image by \( Q_i \) where \( 1 \leq i \leq n \) shows in equation 11 call Mean square error (MSE).

\[
MSE = \frac{1}{n} \sum_{j=1}^{n} (P_i - Q_i)^2
\]

(11)

Figure 4 shows original image (2018) 83 Kb from camera XENICS XTM 640-CL LWIR like grayscale.

![Figure 4](image-url)
Figure 5 shows representation image 83 KB from DCT to IDCT in LabView programming. In Figure 5 that source image from RGB change to YCbCr. MSE is 2.40344 that small and quality image from restored image is good. Figure 6 shows representation language programming from DCT to IDCT in LabView programming 2013. Source image from camera XENICS in left down size 640 x 480. Source image camera XENICS convert to source image block pixel 8x8 in left up. IDCT block 8x8 pixel in the restored image. The pixel value in right down. Figure 7 shows original image (2018) 151 KB from camera HP ASUS Zenfone 2 like color RGB. Figure 8 shows representation image 151 KB from DCT to IDCT in LabView programming.

Source image from camera Handphone ASUS Zenfone 2 in left down size 799 x 1422. Source image camera Handphone ASUS Zenfone 2 convert to source image block pixel 8x8 in left up. IDCT block 8x8 pixel in the restored image. The pixel value in right down. In Figure 8 that source image from RGB change to YCbCr. MSE is 1.79462 that more less than Figure 5 and quality image from restored image is more better than figure 5. Figure 8 is bigger byte than Figure 5 because Figure 5 is grayscale size 640x480 and Figure 8 is color size 799x1422. The byte in color bigger than grayscale if the same size. Figure 8 is bigger than Figure 5 because size 799x1422 in Figure 8 is bigger than size 640x480 in Figure 5.

![Figure 5. Structure representation image 83 Kb form DCT to IDCT.](image_url)
Figure 6. Language programming from DCT to IDCT in LabView programming 2013.

Figure 7. Original image 151 Kb form camera Handphone ASUS Zenfone 2.
4. Conclusion
When performing YCbCr to RGB conversion then the resulting RGB pixel values have a nominal range of 16 – 235 with possible occasional values in 0 – 15 and 236 – 255. Bigger MSE smaller quality image. The compression speed and decompression speed in JPEG standard is fast. Disadvantage for the compression method in JPEG standard is not suitable for all type of compression methods like JPEG 2000.

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