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Implementation of Various JPEG Algorithm for Image Compression

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ABSTRACT

In this work we have implemented the Baseline JPEG standard using MATLAB. We have done both the encoding and decoding of grayscale images in JPEG. With this project we have also shown the differences between the compression ratios and time spent in encoding the images with two different approaches viz-a-viz classic DCT and fast DCT. The project also shows the effect of coefficients on the image restored. The steps in encoding starts with first dividing the original image in 8X8 blocks of sub- images. Then DCT is performed on these sub-images separately. And it is followed by dividing the resulted matrices by a Quantization Matrix. And the last step in algorithm is to make the data one-dimensional which is done by zigzag coding and compressed by Huffman coding, run level coding, or arithmetic coding. The decoding process takes the reverse process of encoding. Firstly, the bit-stream received is converted back into two-dimensional matrices and multiplied back by Quantization Matrix. Then, the Inverse DCT is performed and the sub-images are joined together to restore the image. In this paper we have discuss JPEG compression using MATLAB in particular we are using DCT, Zig zag, compressed by Huffman coding, run level coding or arithmetic coding.

Keywords : DCT, Zigzag, Image Processing, Image Compression

I. INTRODUCTION

Image

Basically, an image is a rectangular array of dots, called pixels. The size of the image is the number of pixels (width x height). Every pixel in an image is a certain color. When dealing with a black and white (where each pixel is either totally white, or totally black) image, the choices are limited since only a single bit is needed for each pixel. This type of image is good for line art, such as a cartoon in a newspaper. Another type of colorless image is a grayscale image. Grayscale images, often wrongly called “black and white” as well, use 8 bits per pixel, which is enough to represent every shade of gray that a human eye can distinguish. When dealing with color images, things get a little trickier. The number of bits per pixel is called the depth of the image (or bit plane). A bit plane of n bits can have 2n colors. The human eye can distinguish about 224 colors, although some claim that the number of colors the eye can distinguish is much higher. The most common color depths are 8, 16, and 24 (although 2-bit and 4-bit images are quite common, especially on older systems).

There are two basic ways to store color information in an image. The most direct way is to represent each pixel's color by giving an ordered triple of numbers, which is the combination of red, green, and blue that comprise that particular color. This is referred to as an RGB image. The second way to store information about color is to use a table to store the triples, and use a reference into the table for each pixel. This can

markedly improve the storage requirements of an image.

Transparency

Transparency refers to the technique where certain pixels are layered on top of other pixels so that the bottom pixels will show through the top pixels. This is sometime useful in combining two images on top of each other. It is possible to use varying degrees of transparency, where the degree of transparency is known as an alpha value. In the context of the Web, this technique is often used to get an image to blend in well with the browser's background. Adding transparency can be as simple as choosing an unused color in the image to be the "special transparent" color, and wherever that color occurs, the program displaying the image knows to let the background show through.

Necessity

In our high stress, high productivity society, efficiency is key. Most people do not have the time or patience to wait for extended periods of time while an image is downloaded or retrieved. In fact, it has been shown that the average person will only wait 20 seconds for an image to appear on a web page. Given the fact that the average Internet user still has a 28k or 56k modem, it is essential to keep image sizes under control. Without some type of compression, most images would be too cumbersome and impractical for use. Note that even high speed Internet users require over one second to download the image.

II. LITERATURE SURVEY

1. Image Compression is achieved by removing the redundancy in the image. Redundanciesin the image can be classified into three categories; inter-pixel or spatial redundancy, psycho visual redundancy and coding redundancy. Inter-pixel Redundancy: Natural images have high degree of correlation among its pixels. This correlation is referred as inter-pixel redundancy or spatial redundancy and is removed by either predictive coding or transform coding. Psycho-visual redundancy: Images are normally meant for consumption of human eyes, which does not respond with equal sensitivity to all visual information. The relative relevancy of various image information components can be exploited to eliminate or reduce any amount of data that is psycho-visually redundant. The process, which removes or reduces Psycho-visual redundancy, is referred as quantization. Coding redundancy: variable-length codes matching to the statistical model of the image or its processed version exploits the coding redundancy in the image.

2. Lossy compression: An Image may be lossy compressed by removing information, which are not redundant but irrelevant (psycho visual redundancy). Lossy-compression introduces certain amount of distortion during compression, resulting in more compression efficiency. Transform based Image compression Image coding techniques based on transform use a mathematical transform to map the image pixel values onto a set of de-correlated coefficients, thereby removing inter-pixel redundancy. These coefficients are then quantized (psycho-visual redundancy), and encoded (coding efficiency). The key factor for the success of transform-based coding schemes is their excellent energy compaction property i.e. large fraction of total energy of image is packed in few coefficients. Most of the transform coefficients for natural images have small magnitudes and can be quantized and encoded or discarded without causing significant loss of information.

3. Image Compression Using Wavelet Transform The Discrete Wavelet Transform (DWT) is the transform adopted by the recent image compression standard JPEG2000 and is most popular transform employed in image coding nowadays. It significantly outperforms algorithms based on other transforms, such as the DCT. The success of the DWT lies in ease of computation and its decomposition of an image into spatial sub bands that facilitates the design of efficient quantization algorithms and allows exploitation of the human visual system

characteristics. The main advantage of wavelet transforms is that they are capable of representing an image with multiple levels of resolution, and yet maintain the useful compaction properties of the DCT, therefore the subdivision of the input image into smaller sub images is no longer necessary as is done in DCT based coding. An important property of wavelet transform is the conservation of energy (sum of square of pixel values). Wavelet transform results in energy of the image divided between approximation and details images, but the total energy remains constant

III. SYSTEM DEVLOPMENT

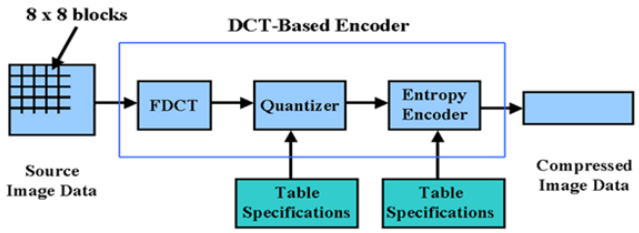


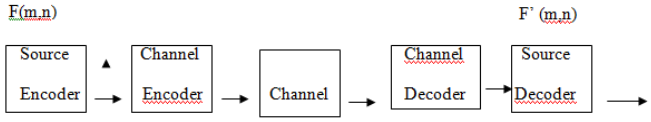
Figure 3.1. DCT-Based Encoder Processing Steps

a) Forward Discrete Cosine Transform (FDCT): The still images are first partitioned into non-overlapping blocks of size 8x8 and the image samples are shifted from unsigned integers and signed integers, where p is the number of bits (here,). The theory of the DCT has been already discussed and will not be repeated here. It should however be mentioned that to preserve freedom for innovation and customization within implementations, JPEG neither specifies any unique FDCT algorithm, nor any unique IDCT algorithms. p = 8. The implementations may therefore differ in precision and JPEG has specified an accuracy test as a part of the compliance test.

b) Quantization: Each of the 64 coefficients from the FDCT outputs of a block is uniformly quantized according to a quantization table. Since the aim is to compress the images without visible artifacts, each step-size should be chosen as the perceptual threshold or for "just noticeable distortion". Psycho-visual experiments have led to a set of quantization tables and these appear in ISO-JPEG standard as a matter of information, but not a requirement. The quantized coefficients are zig-zag scanned, The DC coefficient is encoded as a difference from the DC coefficient of the previous block and the AC coefficients are encoded into (run, level) pair.

c) Entropy Coder: This is the final processing step of the JPEG encoder. The JPEG standard specifies two entropy coding methods – Huffman and arithmetic coding. The baseline sequential JPEG uses Huffman only, but codecs with both methods are specified for the other modes of operation. Huffman coding requires that one or more sets of coding tables are specified by the application. The same table used for compression is used needed to decompress it. The baseline JPEG uses only two sets of Huffman tables – one for DC and the other for AC.

Image compression model



Although image compression models differ in the way they compress data, there are many general features that can be described which represent most image compression algorithms. The source encoder is used to remove redundancy in the input image. The channel encoder is used as overhead in order to combat channel noise. A common example of this would be the introduction of a parity bit. By introducing this overhead, a certain level of immunity is gained from noise that is inherent in any storage or transmission system. The channel in this model could be either a communication link or a storage/retrieval system. The job of the channel and source decoders is to basically undo the work of the source and channel encoders in order to restore the image.

IV. SOFTWARE AND TOOLS

MATLAB (matrix laboratory) is a multi-paradigm numerical computing environment. A proprietary programming language developed by Math Works, MATLAB allows matrix manipulations, plotting of functions and data, implementation of algorithms, creation of user interfaces, and interfacing with programs written in other languages, including C, C++, C#, Java, Fortran and Python.

Although MATLAB is intended primarily for numerical computing, an optional toolbox uses the MuPAD symbolic engine, allowing access to symbolic computing abilities. An additional package, Simulink, adds graphical multi-domain simulation and model-based design for dynamic and embedded system.

V. MATLAB LANGAUGE SYNTAX

if, elseif, else	Execute statements if condition is true
for	for loop to repeat specified number of times
parfor	Parallel for loop
switch, case, otherwise	Execute one of several groups of statements
try, catch	Execute statements and catch resulting errors
while	while loop to repeat when condition is true
break	Terminate execution of for or while loop
continue	Pass control to next iteration of for or while loop
end	Terminate block of code, or indicate last array index
pause	Stop MATLAB execution temporarily
return	Return control to invoking function

VI. CONCLUSION

The JPEG algorithm was created to compress photographic images, and it does this very well, with high compression ratios. It also allows a user to choose between high quality output images, or very small output images. The algorithm compresses images in 4 distinct phases, time, or better. It also inspired many other algorithms that compress images and video, and do so in a fashion very similar to JPEG. Most of the variants of JPEG take the basic concepts of the JPEG algorithm and apply them to more specific problems.

Due to the immense number of JPEG images that exist, this algorithm will probably be in use for at least 10 more years. This is despite the fact that better algorithms for compressing images exist, and even better ones than those will be ready in the near future.

VII. FUTURE SCOPE

This type of compression can be applied in Medical Imaging, where doctors need to focus on image details, and in Surveillance Systems, when trying to get a clear picture of the intruder. JPEG image compression could be used to compress tomographic images and it may be useful in PACS and telemedicine. Further work can be done in the direction of combining the DCT block coding technique with adaptive image partitioning so as to use a smaller block size for an edge block and a larger block size for a shaded block. Image processing and data compression, a range of new ideas which aim at developing indexing algorithms with transform-based image compression and other state-of-the art techniques are under investigation. The research could also be well extended to other image processing areas such as face recognition, edge detection and video editing. One will be able to propose an efficient algorithm to represent and code the adaptive partition and then extend this adaptive partition-based approach to low bit rate video coding, by adapting the coding rate to the importance of the image regions of the video object considered in the scene. The recognition of handwritten numerals is a challenging problem in pattern recognition. Additional research must be performed to improve the quality of the reconstructed image, use of larger range blocks and more wavelet decomposing levels may be researched to get higher compression ratio.

ADVANTAGES

- ✓ JPEG format has been in use since long time and is extremely portable.
- ✓ JPEG format is compatible with almost every image processing application.
- ✓ JPEG format is compatible with most of the hardware devices e.g printers etc; therefore it is very easy to print the images in JPEG format.
- ✓ JPEG format can be used to store high resolution fast moving images which would be blur in other image formats because owing to their small size, JPEG images can be stored quickly from a camera to storage device.
- ✓ Size of JPEG images can be reduced and compressed which makes this file format suitable for transferring images over the internet because it consumes less bandwidth. A JPEG image can be compressed down to 5% of its original size.

DISADVANTAGES

- ✓ JPEG compression technique is a lossy compression. Lossy compression means that after image is compressed in JPEG format, it loses certain actual contents of the image.
- ✓ Quality of Image is reduced after JPEG compression owing to the loss of actual content of the image.
- ✓ JPEG image compression is not suitable for images with sharp edges and lines. JPEG image format is not capable of handling animated graphic images.
- ✓ JPEG images do not support layered images. Graphic designer need to work on layered images in order to manipulate and edit graphic images which is not possible with JPEG Images.
- ✓ Only 8 bit images are supported by JPEG format. On the other hand, modern high resolution digital cameras support 10, 12, 14 or 16 bit images. If these images are stored in JPEG format, extra information is discarded, resulting in decreased image quality.

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