IMAGE PROCESSING

Image Compression

Ch5

Image Compression

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.

In general, Image compression involves reducing the size of image data files, while retaining necessary information. The reduced file is called the compressed file and is used to reconstruct the image, resulting in the decompressed image. The original image, before any compression is performed, is called the uncompressed image file. The ratio of original uncompressed image file and the compressed file is referred to as the compression ratio. It is often written as $SIZE_U:SIZE_C$. The compression ratio is denoted by:

Image Compression

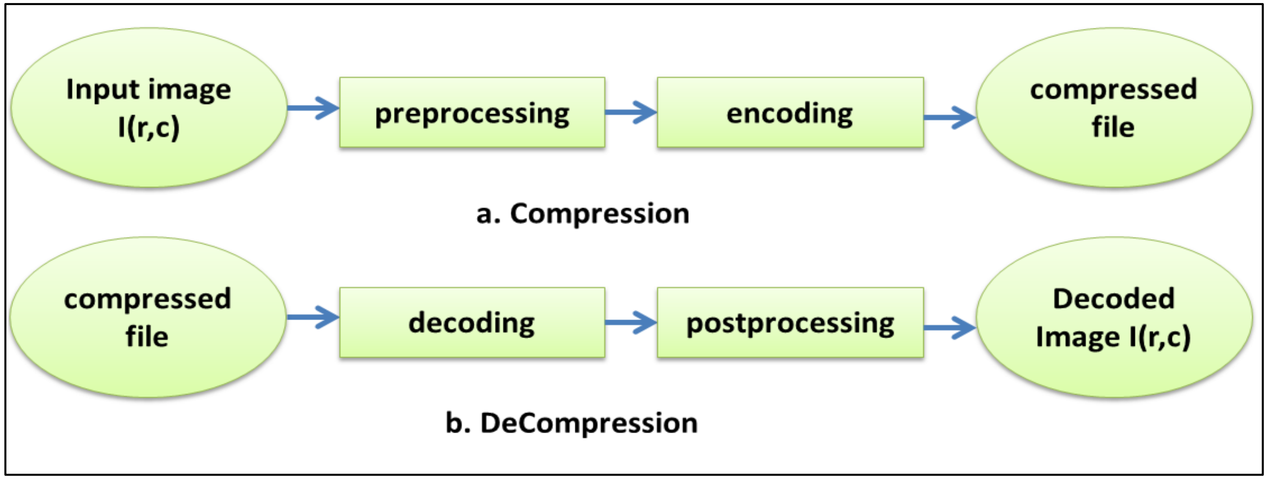
$$\textbf{Compression Ratio} = \frac{\textbf{Uncompressed File Size}}{\textbf{Compressed File Size}} = \frac{SIZE_U}{SIZE_C}$$

EXAMPLE :The original image is 256x256 pixels , 8 bits per pixel. This file is 65,536 bytes. After compression the image file is 6,554 bytes. The compression ratio is: $SIZEL_U/SIZE_C$= 65536/6554 = 9.999 = 10. This can also be written as 10:1.

The reduction in file size is necessary to meet the bandwidth requirements for many transmission systems, the storage requirements in computer database.

The main goal of such system is to reduce the storage quantity as much as possible, and the decoded image displayed in the monitor can be similar to the original image as much as can be.

Compression System Model



The compression system model consists of two parts: Compressor and Decompressor.

1. Compressor: consists of preprocessing stage and encoding stage.
2. Decompressor: consists of decoding stage followed by a post processing stage.

Before encoding, preprocessing is performed to prepare the image for the encoding process, and consists of any number of operations that are application specific. After the compressed file has been decoded, post processing can be performed to eliminate some of the undesirable artifacts brought about by the compression process. Often, many practical compression algorithms are a combination of a number of different individual compression techniques.

Compression System Model

The compressor consists of :-

- Preprocessing stage: preprocessing is performed to prepare the image for the encoding process, and consists of any number of operations that are application specific.
  - Data reduction, Here, the image data can be reduced by gray-leve1 and/or spatial quantization, or they can undergo any desire image enhancement (for example, noise removal) process.
  - The mapping process, which maps the original image data into another mathematical space where it is easier to compress the data.
- Encoding stage.
  - The quantization stage (as part of the encoding process), which takes the potentially continuous data from the mapping stage and puts it in discrete form.
  - Final stage of encoding involves coding the resulting data, which maps the discrete data from the quantized onto a code in an optimal manner. A compression algorithm may consist of all the stages, or it may consist of only one or two of the stage.

Compression System Model

The Decompressor consists of :-

- decoding process is divided into two stages.
  - the decoding stage, takes the compressed file and reverses the original coding by mapping the codes to the original, quantized values.
  - Next, these values are processed by a stage that performs an inverse mapping to reverse the original mapping process. Finally.
- A postprocessing stage: After the compressed file has been decoded, postprocessing can be performed to eliminate some of the potentially undesirable artifacts brought about by the compression process. The Image postprocessed to enhance the look of the final image. Often, many practical compression algorithms are a combination of a number of different individual compression techniques.

Images Compression Methods

For digital images, data refer to pixel gray-level values the correspond to the brightness of a pixel at a point in space. Information is interpretation of the data in a meaningful way. Data are used to convey information, much like the way the alphabet is used to convey information via words. Information is an elusive concept, it can be application specific. For example, in a binary image that contains text only, the necessary information may only involve the text being readable, whereas for a medical image the necessary information may be every minute detail in the original image.

There are two primary types of images compression methods and they are:

1. Lossless Compression
2. Lossy Compression.

Images Compression Methods

1-Lossless Compression

This compression is called lossless because no data are lost, and the original image can be recreated exactly from the compressed data. For simple image such as text-only images.

There are two methods of lossless comparison:

- **Huffman Coding**
- **Run-Length Coding**

2-Lossy Compression.

These compression methods are called Lossy because they allow a loss in actual image data, so original uncompressed image can not be created exactly from the compressed file. For complex images these techniques can achieve compression ratios of 100 0r 200 and still retain in high – quality visual information.

1-Lossless Compression

➢ Huffman Coding

The Huffman code developed by D. Huffman in1952, is a minimum length code.

This means that given the statistical distribution of the gray levels (the histogram),

The Huffman algorithm will generate a code that is as close as possible to the minimum bound' the entropy'. For example, Huffman coding alone will typically reduce the file by 10 to 50%, but this ratio can be improved to 2:1 or 3:1 by preprocessing for irrelevant information removal.

Note (symbols with less information require fewer bits to represent them. From the example we can see that the Huffman code is highly dependent on the histogram, so any preprocessing to the histogram may help the compression ratio.

1-Lossless Compression

- **Run-Length Coding**

Run-length coding (RLC) is an image compression method that works by counting the number of adjacent pixels with the same gray-level value. This count, called the run length, is then coded and stored. Here we will explore several methods of run-length coding basic methods that are used primarily for binary (two-valued) images and extended versions for gray-scale images. Basic RLC is used primarily for binary images but can work with complex images that have been preprocessed by thresholding to reduce the number of gray levels to two.

Images Compression Methods

Differences between lossy and lossless compression

Lossless Compression	Lossy Compression
1. All original data can be recovered when the file is uncompressed every single bit of data that was originally in the file remains after the file is uncompressed. 2. All of the information is completely restored. 3. This is generally the technique of choice for text or spreadsheet files, where losing words or financial data could pose a problem. 4. The Graphics Interchange File (GIF) is an image format used on the Web that provides lossless compression.	1. Reduces a file by permanently eliminating certain information, especially redundant information. 2. When the file is uncompressed, only a part of the original information is still there (although the user may not notice it). 3. Lossy compression is generally used for video and sound where a certain amount of information loss will not be detected by most users. 4. The JPEG image file, commonly used for photographs and other complex still images on the Web, is an image that has lossy compression.

Fidelity Criteria

Fidelity criteria can be divided into two classes: objective and subjective fidelity criteria. The objective fidelity criteria are borrowed from digital signal processing and information theory and provides equations that can be used to measure the amount of error in the reconstructed (decompressed) image. Subjective fidelity criteria require the definition of a qualitative scale to assess image quality. Human visual test subjects to determine image fidelity can then use this scale. In order to provide unbiased results, evaluation will subjective measures require careful selection of the test subjects and carefully designed evaluation experiments. The objective criteria although widely used are not necessary correlated with our perception of image quality.

Fidelity Criteria

The commonly used objective measures are the Root Mean Square Error (E_{RMS}), the Signal-to-Noise-Ratio (SNR), and the Peak- Signal-to-Noise-Ratio (PSNR). The error between an original and reconstructed pixel values can be defined as:

$$Error(r,c) = I^{\wedge}(r,c) - I(r,c)$$

Where

$I(r,c)$: is the original image.

$I^{\wedge}(r,c)$: is a reconstructed image.

Next, The total error between the original and (decompressed) image of size (M * N) can be defined as :

$$Totalerror = \sum_{r=0}^{M-1} \sum_{c=0}^{N-1} \left[I^{\wedge}(r,c) - I(r,c) \right]$$

HSL color Scheme

Fidelity Criteria

The MSE is found by taking the sum of the squared errors divided by the total number of pixels in the image "mean" as follows:

$$MSE = \frac{1}{N * M} \sum_{r=0}^{M-1} \sum_{c=0}^{N-1} \left[I^{\wedge}(r,c) - I(r,c) \right]$$

So, the Root Mean Square Error (E_{RMS}) is as follows:

$$E_{RMS} = sqrt(MSE) = \sqrt{\frac{1}{N * M} \sum_{r=0}^{M-1} \sum_{c=0}^{N-1} \left[I^{\wedge}(r,c) - I(r,c) \right]^2}$$

The smaller value of the error metrics, the better the reconstructed (decompressed) image represent the original image. Alternatively, with the SNR metrics, a large number implied a better image.

Fidelity Criteria

The SNR metrics consider the reconstructed (decompressed) image I^(r,c) to be the "signal", and the error to be the "noise". So, SNR can be defined as:

$$SNR = \sqrt{\frac{\sum_{r=0}^{M-1}\sum_{c=0}^{N-1}\left[I^{\wedge}(r,c)\right]^2}{\sum_{r=0}^{M-1}\sum_{c=0}^{N-1}\left[I^{\wedge}(r,c) - I(r,c)\right]^2}}$$

Another popular error measurement is the PSNR. It is based upon the sum of the square difference between corresponding pixels of the reconstructed image and the reference (original) image. The exact formula is given below:

$$PSNR = 10\log_{10}\frac{(L-1)^2}{\frac{1}{N*M}\sum_{r=0}^{M-1}\sum_{c=0}^{N-1}\left[I^{\wedge}(r,c) - I(r,c)\right]^2}$$

Where L is the number of gray levels.

Fidelity Criteria

These objective measures are often used because they are easy to generate seemingly unbiased. Under normal circumstances these objective measures (E_{RMS}, SNR and PSNR) are good indicator of image quality, but remember that these metrics are not necessarily correlated to human perception of an image.

The subjective measures are a better method for comparison algorithm if the goal is to achieve high-quality images as defined by our visual perception.

Subjective testing is performed by creating a database of images by gathering a group of people that are representative of the desired population, are having all test subjects evaluate the image according to predefined scoring criteria results are then analyzed statistically; typically using the averages and standard devised as a metrics.

Fidelity Criteria

subjective fidelity measures can be classified into three categories.

The first type is referred to as impairment tests, where the test subjects score the images in term how bad they are.

The second type is quality tests, where the test subjects rate the image terms of how good they are.

The third type is called comparison tests, where the image evaluated on a side-by-side basis. The comparison type tests are considered to provide people to determine.

Impairments and quality test require an absolute measure, where more difficult to determine in an unbiased fashion.