

Image compression using a raspberry pi

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Abstract – An image contains large amount of digital data and it is necessary to reduce digital data volume for transmission and preservation by using image compression. This paper mainly concentrates on image compression using Raspberry Pi processor which helps to preserve large number of images and in retaining its quality. Raspberry Pi processor allows the implementation of most widely used 2-D Discrete Wavelet Transform (DWT) compression method to give the Joint Photographic Experts Group (JPEG) format using Open CV platform. We will use an approach similar to the JPEG2000 algorithm to implement both the encoding and decoding of images captured. We obtain images at regular intervals using a USB camera which is connected to a raspberry pi at a remote location. We compress the image and send it through the internet which requires a compressed version of the image to ensure better transmission speed and effective utilization of bandwidth as well as better utilization of memory. The server receives the compressed image, decompresses the image and displays the image. Compression is done by applying the wavelet transform to the image, quantizing the transformed matrix and then encoding. The reverse process is used for decompressing the image for image recovery

Keywords— *JPEG compression, DCT, Raspberry Pi, Python, Open CV, quality factor.*

I. INTRODUCTION

Image compression is a type of data compression applied to digital images, to reduce their cost for storage or transmission. Image compression may be lossy or lossless. Lossless compression is preferred for archival purposes and often for medical imaging, technical drawings, clip art, or comics. Lossy compression methods, especially when used at low bit rates, introduce compression artifacts. Lossy methods are especially suitable for natural images such as photographs in applications where minor (sometimes imperceptible) loss of fidelity is acceptable to achieve a substantial reduction in bit rate. Lossy compression that produces negligible differences may be called visually lossless.

Digitization process results in a large number of bits for each image. However, the number of bits actually required to represent the information in an image may be

substantially less because of redundancy. In general 3 types of redundancy in digital images can be identified:

- [1] Spatial redundancy, which is due to the correlation (or dependence) between neighbouring pixel values.
- [2] Spectral redundancy which is due to the correlation between different colour planes(e.g. In an RGB colour image) or spectral bands(e.g. aerial photographs in remote sensing)
- [3] Temporal redundancy which is due to correlation between different frames in a sequence of images.

Image compression research aims to reduce the number of bits required to represent an image by removing these redundancies. In addition, it seeks to establish fundamental limits on the performance of any compression scheme for a given class of images. This is done using information theory concepts. Beyond these basic goals it is also necessary to develop a variety of algorithms suited to different applications .There are many applications to image compression .There are many approaches to image compression but they can be classified into two fundamental groups: lossy and lossless

In lossless compression,(also known as bit preserving or reversible compression),the reconstructed image after compression is numerically identical to the original image on a pixel-to-pixel basis. Obviously, lossless compression is ideally desired since no information is compromised .However, only a modest amount of compression is possible.

In lossy compression (also known as irreversible compression), the reconstructed image contains degradations relative to the original. As a result much higher compression can be achieved as compared to lossless compression. In general, more compression is obtained at the expense of more distortion. It is important to note that these degradations may or may not be visually apparent. In fact, the term visually lossless has often been used to characterize lossy compression schemes that result in no visible loss under normal viewing conditions. Unfortunately the definition of visually lossless is quite subjective and extreme caution should be taken in its interpretation. It is conceivable that an algorithm that is visually lossless under certain viewing conditions e.g. a 19

inch video on monitor viewed at a distance of 4 feet could result in visible degradations under more stringent viewing conditions such as 14×17 inch secondary image printed on film.

These two categories can be further divided based on the nature of the original input image. The image may either be binary e.g. text or documents, or continuous-tone e.g. 8-bit video, 12-bit medical images, etc. It may be either a still image which contains spatial redundancy (and spectral redundancy if a color image), or it may be a sequence of images e.g. Motion pictures, which contains temporal redundancy as well.

Methods for lossless image compression are:

- Run-length encoding – used in default method in PCX and as one of possible in BMP, TGA, TIFF
- Area image compression
- DPCM and Predictive Coding
- Entropy encoding
- Adaptive dictionary algorithms such as LZW – used in GIF and TIFF
- Deflation – used in PNG, MNG, and TIFF
- Chain codes

Methods for lossy compression:

- Reducing the color space to the most common colors in the image. The selected colors are specified in the color palette in the header of the compressed image. Each pixel just references the index of a color in the color palette, this method can be combined with dithering to avoid posterization.
- Chroma sub sampling. This takes advantage of the fact that the human eye perceives spatial changes of brightness more sharply than those of color, by averaging or dropping some of the chrominance information in the image.
- Transform coding. This is the most commonly used method. In particular, a Fourier-related transform such as the Discrete Cosine Transform (DCT) is widely used: N. Ahmed, T. Natarajan and K.R.Rao, "Discrete Cosine Transform," *IEEE Trans. Computers*, 90-93, Jan. 1974. The DCT is sometimes referred to as "DCT-II" in the context of a family of discrete cosine transforms; e.g., see discrete cosine transform. The more recently developed wavelet transform is also used extensively, followed by quantization and entropy coding.
- Fractal compression.

A. DISCRETE WAVELET TRANSFORM

$$\psi_{a,b}(t) = \frac{1}{\sqrt{a}} \psi\left(\frac{t-b}{a}\right)$$

The discrete wavelet transform (DWT) is an implementation of the wavelet transform using a discrete set of the wavelet scales and translations obeying some defined rules. In other words, this transform decomposes the signal into mutually orthogonal set of wavelets, which is the main difference from the continuous wavelet transform (CWT), or its implementation for the discrete time series sometimes called discrete-time continuous wavelet transform (DT-CWT).

The wavelet can be constructed from a scaling function which describes its scaling properties. The restriction that the scaling functions must be orthogonal to its discrete translations implies some mathematical conditions on them which are mentioned everywhere, e.g. the dilation equation

where S is a scaling factor (usually chosen as 2). Moreover, the area between the function must be normalized and scaling function must be orthogonal to its integer translations, i.e.

After introducing some more conditions (as the restrictions above does not produce a unique solution) we can obtain results of all these equations, i.e. the finite set of coefficients ak that define the scaling function and also the wavelet. The wavelet is obtained from the scaling function as N where N is an even integer. The set of wavelets then forms an orthonormal basis which we use to decompose the signal. Note that usually only few of the coefficients ak are nonzero, which simplifies the calculations.

In the following figure, some wavelet scaling functions and wavelets are plotted. The most known family of orthonormal wavelets is the family of Daubechies. Her wavelets are usually denominated by the number of nonzero coefficients $a k$, so we usually talk about Daubechies 4, Daubechies 6, etc. wavelets. Roughly said, with the increasing number of wavelet coefficients the functions become smoother. See the comparison of wavelets Daubechies 4 and 20 below. Another mentioned wavelet is the simplest one, the Haar wavelet, which uses a box function as the scaling function.

The wavelet transform (WT) has gained widespread acceptance in signal processing and image compression. Because of their inherent multi-resolution nature, wavelet-coding schemes are especially suitable for applications where *scalability* and *tolerable degradation* are important. Recently the JPEG committee has released its new image coding standard, JPEG-2000, which has been based upon DWT.

Wavelet transform decomposes a signal into a set of basis functions. These basis functions are called wavelets. Wavelets are obtained from a single prototype wavelet $y(t)$ called mother wavelet by dilations and shifting:

Where a is the scaling parameter and b is the shifting parameter

$$-0.2 \ 0 \ 0.2 \ 0.4 \ 0.6 \ 0.8 \ 1 \ 1.2 \ \dots \ 0 \ 0.5 \ 1 \ 1.5 \ 2 \ 2.5 \ 3 \ 3.5 \ 4$$

The 1-D wavelet transform is given by :

The inverse 1-D wavelet transform is given by:

2-D DWT for Image:

Advantages of DWT over DCT :

- No need to divide the input coding into non-overlapping 2-D blocks, it has higher compression ratios avoid blocking artifacts.
- Allows good localization both in time and spatial frequency domain.
- Transformation of the whole image \rightarrow introduces inherent scaling
- Better identification of which data is relevant to human perception \rightarrow higher compression ratio (64:1 vs. 500:1)

B. JPEG QUANTISATION

Quantization, involved in image processing, is a lossy compression technique achieved by compressing a range of values to a single quantum value. When the number of discrete symbols in a given stream is reduced, the stream becomes more compressible. Specific applications include DCT data quantization in JPEG and DWT data quantization in JPEG 2000.

The human eye is fairly good at seeing small differences in brightness over a relatively large area, but not so good at distinguishing the exact strength of a high frequency (rapidly varying) brightness variation. This fact allows one to reduce the amount of information required by ignoring the high frequency components. This is done by simply dividing each component in the frequency domain by a constant for that component, and then rounding to the nearest integer. This is the main lossy operation in the whole process. As a result of this, it is typically the case that many of the higher frequency components are rounded to zero, and many of the rest become small positive or negative numbers. As human vision is also more sensitive to luminance than chrominance, further compression can be obtained by working in a non-RGB color space which

separates the two (e.g., YCbCr), and quantizing the channels separately. The quantisation matrix taken must have weighing factors which can enable maximum compression with a minimum loss of detail

C. ARITHMETIC ENCODING

Arithmetic coding is a form of entropy encoding used in lossless data compression. Normally, a string of characters such as the words "hello there" is represented using a fixed number of bits per character, as in the ASCII code. When a string is converted to arithmetic encoding, frequently used characters will be stored with fewer bits and not-so-frequently occurring characters will be stored with more bits, resulting in fewer bits used in total. Arithmetic coding differs from other forms of entropy encoding, such as Huffman coding, in that rather than separating the input into component symbols and replacing each with a code, arithmetic coding encodes the entire message into a single number, an arbitrary-precision fraction q where $0.0 \leq q < 1.0$, or denoted in interval as $[0.0 \leq n < 1.0)$. It represents the current information as a range, defined by two numbers. Recent Asymmetric Numeral Systems family of entropy coders allows for faster implementations thanks to directly operating on a single natural number representing the current information.



Original image



Compressed Image

CONCLUSIONS

. The algorithm used is to ensure at least 20% increase in the compression ratios that were observed in the older jpeg compression algorithm due to the discrete wavelet transform that was used instead of the conventional discrete cosine transform. This algorithm for image compression is similar to the jpeg2000 algorithm is not widely used due to the large number of conventional jpeg format and lesser observable differences in storage space .This method can be used to compress png,jpg ,jp2 or any other image type .However this can be an ideal method to transmit more classified images with a lesser risk of hackers manipulating or intercepting the images that are to be sent to the server. Therefore this not only ensures faster transmission but also ensures better safety than the conventional jpeg algorithms to compress and transmit data or images using this method.

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