THE MODULATION OF LOHSCHELLER QUANTIZATION MATRIX IN THE JPEG COMPRESSION METHOD

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Abstract

Many useful applications, image compression method is useful and of interest such as in the area of industrial processes, in the field of biomedicine, storage security, video simulation to mention something. This method is of great importance for a user to a specialist to manage the amount of information contained in the images. This work presents for such applications, an image compression based on a variation of quantification Lohscheller matrix "LH", this in the stage of quantization of the standard image compression method schema. A loss compression scheme is the Joint Photographic Experts Group, in which there is an intermediate stage of quantification by an already established LH matrix known as Lohscheller. The way to quantify is to divide the block of an "M" matrix of 8x8 (64-bit) image obtained previously processed the discrete cosine transform (DCT) two-dimensional (2D) between the LH matrix of the same dimensions and rounding the result to the nearest integer value. Then, to carry out modulation multiplies the LH matrix by a factor □ between 0 and 1, with best results in the process of image compression. These results are better as regards the size of the compressed image. It presents the results obtained in graphs of modular matrix LH of an image of 512x512 – pixels, its size and its rate of compression. Also occurs as return or recover the original values of the image there is any loss in shades of color, but these are not very meaningful for the application.

Resumen

En muchas aplicaciones útiles, el método de compresión de imágenes es de gran utilidad e interés como por ejemplo en el área de simulación de procesos industriales, en el campo de la biomedicina, en almacenamiento de videos de seguridad, por mencionar algunos. Este método es de gran importancia para un usuario como para un especialista, por el manejo de la cantidad de información contenida en las imágenes.

Este trabajo presenta, para este tipo de aplicaciones, una compresión de imágenes basada en un esquema de variación de cuantificación Lohscheller “LH”, en la etapa de cuantización del método de compresión de imágenes estándar.

Un esquema de compresión de imágenes con pérdida de información es el llamado Joint Photographic Experts Group, en el cual, existe una etapa intermedia de cuantificación mediante una matriz LH ya establecida conocida como Lohscheller. La manera de cuantificar es dividir el bloque de una matriz “M” de 8X8 (64-bit) de una imagen que se obtiene anteriormente de procesar la Transformada Discreta Coseno (DCT) en dos dimensiones (2D), entre la matriz LH de las mismas dimensiones y redondear su resultado a el valor entero más próximo. Luego, para llevar a cabo la modulación se multiplica la matriz LH por un factor τ entre 0 y 1, obteniendo mejores resultados en el proceso de compresión de la imagen. Estos resultados son mejores en cuanto al

tamaño de la imagen comprimida. Se presentan los resultados obtenidos en gráficas después de modular la matriz LH de una imagen de 512X512-bit con respecto a su tamaño y a su porcentaje de compresión. También se presenta como al regresar o recuperar los valores originales de la imagen hay alguna perdida en cuanto a tonos de color, que no son muy significativos para el tipo de aplicación.

Introduction

As informatics progresses, the images have become a very important area of this. Nowadays arise more graphical environments oriented to multiple applications. Images have been made with it, hence the need to compact them, we must reduce the amount of data required to represent a digital image. Compression relies on the elimination of redundant data. Expressed this mathematically, it is equivalent to transform a two dimensional distribution of pixels in a set of statistical data without correlating. This transformation (compression) is applied to the images before they are stored or sent, for example via network. Once at its destination or stored, image is decompressed.

In other words, image compression is to minimize the number of bits required to represent an image. Image compression applications are mainly the transmission and storage. Transmission main applications are television, radar and sonar, teleconferences, communication by computers and transmission by fax and so on. In storage, image compression is used on documents, medical imaging, image sequence, images from satellite weather maps, etc. It is also possible to create fast algorithms that work with compressed images with the number of operations required to implement algorithms are reduced.

First image compression (25 years ago) was limited to compress bandwidth transmission of video using analog methods. With the advent of digital computers, analog compression methods were giving way to digital compression. Currently taken various international standards, it has made this area has progressed significantly. This has partly been due to the implementation of the theoretical works to initiate C.E. Shannon around 1940. Probabilistic information vision was first developed as well as their representation, streaming, compression and transmission.

Image compression is now crucial, in order to be storage and transmitted this information with the growth of multimedia computing (computers are used to videoproduction, broadcast, etc.). It is also very important the role played in topics such as videoconference, medical imaging, dispatch of FAX, remote control of military applications, etc.

Some techniques implemented to achieve compaction of an image is JPEG (Joint Photographic Experts Group), which is a standard for compressing images. As well as JPEG represents a standard for the compaction of images in video transmission, the equivalent is Motion Pictures Experts Group (MPEG). MPEG can be considered an extension of the JPEG.

Compress JPEG

Joint Photographic Experts Group is currently the most widely used compression method with loss, or not loss image compression. This method uses the discrete cosine transform (DCT), which is calculated using integers, so take advantage of fast computation algorithms. JPEG achieves an adjustable compression quality of the image that you want to rebuild.

Providing a universal standard for minimum compression, the Group of experts photo partners or Joint Photographic Experts Group, developed a format of the digital image storage based on studies of human visual perception (HVP). The JPEG standard describes a family of fixed continuous tonality in grayscale or 24 bit color image compression techniques. However, many applications have used technique also to video, compression because it provides high enough quality to a very good compression ratio image decompression, and requires less power calculation compression MPEG (Motion Pictures Experts Group).

Due to the amount of data involved, and redundancy psicovisual images JPEG uses a loss compression scheme based on encoding transformation. The resulting standard has as many alternatives as they are necessary to serve a wide variety of purposes and nowadays is recognized by the international standards organization ISO 10918 name.

The JPEG standard defines three different coding systems:

• A core coding system with losses, which is based on the discrete cosine transform and is suitable for most applications of compression.

• Extended codification system for greater compression applications, better precision, or progressive reconstruction.

• A lossless, reversible compression independent encoding system.

Lossless encoding is not useful for the video because it provides high compression ratios. Extended encoding is used primarily to provide partial fast decoding an image compressed, so that the overall appearance of this can be determined before the decodific completely. This is also useful for the video since it is constructed of a series of still images, each of which must decode it and displayed at a very rapid pace.

After the supremacy of JPEG as a standard for compressing images for several years, appears a new competitor to it. Due to the increase in the use of multimedia technologies and large technical progress in information technology in recent years, the image compression requires more power as well as new functionality.

Therefore it develops JPEG-2000. Not only it is intended that this standard provides a better subjective quality than JPEG and a higher compression rate, it also offers a rich set of new features that achieve the same success for the new standard to which took his predecessor. Additionally JPEG-2000 has been designed with a multitude of fields of application in mind, all of this and how the new encoding scheme works.

Advantages of JPEG

The JPEG standard has strong acceptance in the computer world, in fact JPEG-2000 are not intended to replace it, only to complement it. This is due to several key factors in JPEG:

- Low consumption of memory, enabling low-cost, for example in digital photo cameras hardware implementations.
- Low complexity of the algorithm, which lowers again, the design of JPEG decoders are chips.
- Reaches a good compression rate of natural image, everything using the visual model.
- Is widely used for the exchange of images in the web, etc.

However, it is a standard with a long history after itself, and over time, the improvement of technologies and the emergence of new applications with demanding requirements requires the emergence of a new standard that overcomes the limitations of JPEG, a subset of them are:

- JPEG only allows a single resolution and quality.
- Compression with loss compression rate is low.
- Strongly compressed images appear famous artifacts square-shaped.
- It is a bit resistant errors, for example, a JPEG in a prone wireless network fault transmission format.
- Not been designed for compression of synthetic images only for natural images.
- Does not support having parts of the image encoded with higher level of detail than others.
- Does not offer good quality of bi-level image compression (B/W).

Due to these factors and advances in research in image compression, it was decided to develop a new standard for compressing images that adapts to new needs in the fields that are required.

Developing

Procedures for image compression. Initialize with an image of 512 X 512 pixels and is divided into small blocks of 8 × 8 pixels, with a section of the original image data.

$$\begin{bmatrix} 52 & 55 & 61 & 66 & 70 & 61 & 64 & 73 \\ 63 & 59 & 55 & 90 & 109 & 85 & 69 & 72 \\ 62 & 59 & 68 & 113 & 144 & 104 & 66 & 73 \\ 63 & 58 & 71 & 122 & 154 & 106 & 70 & 69 \\ 67 & 61 & 68 & 104 & 126 & 88 & 68 & 70 \\ 79 & 65 & 60 & 70 & 77 & 68 & 58 & 75 \\ 85 & 71 & 64 & 59 & 55 & 61 & 65 & 83 \\ 87 & 79 & 69 & 68 & 65 & 76 & 78 & 94 \end{bmatrix}$$

Sub-Matrix array of 8x8 pixels.

After each small block is converted to the frequency domain on discrete two-dimensional cosine transform named DCT.
The following process is subtracting 128 so that numbers environment to 0, between - 128 and 127.
Matrix centered between -128 and 127 values
The basic encoder implements a loss compression algorithm (cannot retrieve decoding exactly as the original image) based on the use of the discrete cosine transform (DCT).

The matrix transformation by DCT and rounding of each element to the nearest integer number.

$$\begin{bmatrix} -415 & -30 & -61 & 27 & 56 & -20 & -2 & 0 \\ 4 & -22 & -61 & 10 & 13 & -7 & -9 & 5 \\ -47 & 7 & 77 & -25 & -29 & 10 & 5 & -6 \\ -49 & 12 & 34 & -15 & -10 & 6 & 2 & 2 \\ 12 & -7 & -13 & -4 & -2 & 2 & -3 & 3 \\ -8 & 3 & 2 & -6 & -2 & 1 & 4 & 2 \\ -1 & 0 & 0 & -2 & -1 & -3 & 4 & -1 \\ 0 & 0 & -1 & -4 & -1 & 0 & 1 & 2 \end{bmatrix}$$

Matrix array after the DCT.

Note that the largest of the entire array element appears in the upper left corner, this is the DC component.

JPEG incorporates the features of the human visual system (HVS) in the compression process. It been shown that the human visual system is more insensitive to high frequency variations. Taking advantage of this quality, picture information is deleted to encode (it is why the system has loss) and exploited this fact to achieve compression.

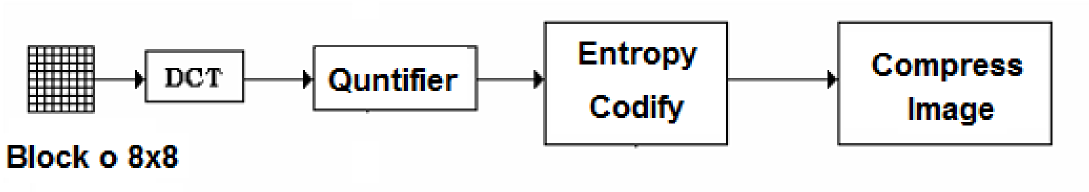


Figure 1. It is a simplified block diagram showing the procedures involved in the JPEG compression.

The decoding is essentially the reverse of the encoding, carried out the same processes, but in reverse order. Specification tables used in the codification process are along with the flow of data after the compression and are used for decompression. Decoder converts bit flow stream into a new table of DCT coefficients. These are then multiplied by coefficients quantification and feedback on the DCT inverse IDCT (inverse discrete cosine transform) process. The output of the process is a reconstructed size 8x8 pixel blocks. Of course, this block of 8x8 pixels not play exactly the original since information was lost in the process of codifying.

Figure 2. Simplified block diagram of the basic process involved in JPEG decompression.

Quantification

As we said, the human eye is very good to detect small changes in brightness in relatively large areas, but not when the brightness changes quickly in small areas (high frequency variation), this allows it to remove high frequencies, without losing excess visual quality. This is done by dividing each component in the frequency domain by a constant for that component, and rounding to the nearest integer number. This is the process in which most of the information (and quality) is lost when an image is processed by this algorithm. The result is that the components of high frequencies tend to equal to zero, while many others, become small positive and negative numbers.

A matrix array of typical quantization is optionally used in the JPEG standard Lohscheller matrix:

$$\begin{bmatrix} 16 & 11 & 10 & 16 & 24 & 40 & 51 & 61 \\ 12 & 12 & 14 & 19 & 26 & 58 & 60 & 55 \\ 14 & 13 & 16 & 24 & 40 & 57 & 69 & 56 \\ 14 & 17 & 22 & 29 & 51 & 87 & 80 & 62 \\ 18 & 22 & 37 & 56 & 68 & 109 & 103 & 77 \\ 24 & 35 & 55 & 64 & 81 & 104 & 113 & 92 \\ 49 & 64 & 78 & 87 & 103 & 121 & 120 & 101 \\ 72 & 92 & 95 & 98 & 112 & 100 & 103 & 99 \end{bmatrix}$$

Matriz Lohscheller "LH" de Cuantización.

By dividing each matrix transform image DCT coefficients between each coefficients matrix of quantification, obtains this array, already quantified:

$$\begin{bmatrix} -26 & -3 & -6 & 2 & 2 & -1 & 0 & 0 \\ 0 & -2 & -4 & 1 & 1 & 0 & 0 & 0 \\ -3 & 1 & 5 & -1 & -1 & 0 & 0 & 0 \\ -4 & 1 & 2 & -1 & 0 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix}$$

Matrix array Quantified.

For example, quantifying the first element, the DC coefficient would thus:

$$\mathrm{round}\left(\frac{-415}{16}\right) = \mathrm{round}\left(-25.9375\right) = -26$$

Quality Factor (τ)

With the aim of achieving greater or lesser compression using quantization obtained by the DCT coefficients, it defines the quality factor. The quality factor is a number between 0 and 1 that modifies JPEG quantization matrix. Keep in mind, if the higher number of the LH matrix, fewer it will be the bits used to represent the component that has been divided.

Results

By modulation matrix Lohscheller image JPEG compression procedure, shown that results have growth behavior in size when τ modulation coefficient increases. On the other hand a decrease in the percentage of compression is observed when the modulation increases.

Table 1. Results of matrix array LH after modulation.

Modulation factor τ	Image size [Kbyte] T_i	Compress Image size, T_{ic} [Kbyte]	Average of compression P_c
0.1	786432	46738	94.06
0.2	786432	61530	92.18
0.3	786432	71890	90.86
0.4	786432	81382	89.65
0.5	786432	90536	88.49
0.6	786432	99042	87.41
0.7	786432	107474	86.33
0.8	786432	115820	85.27
0.9	786432	123930	84.24
1.0	786432	131976	83.22

All this is presented in the next two graphics.

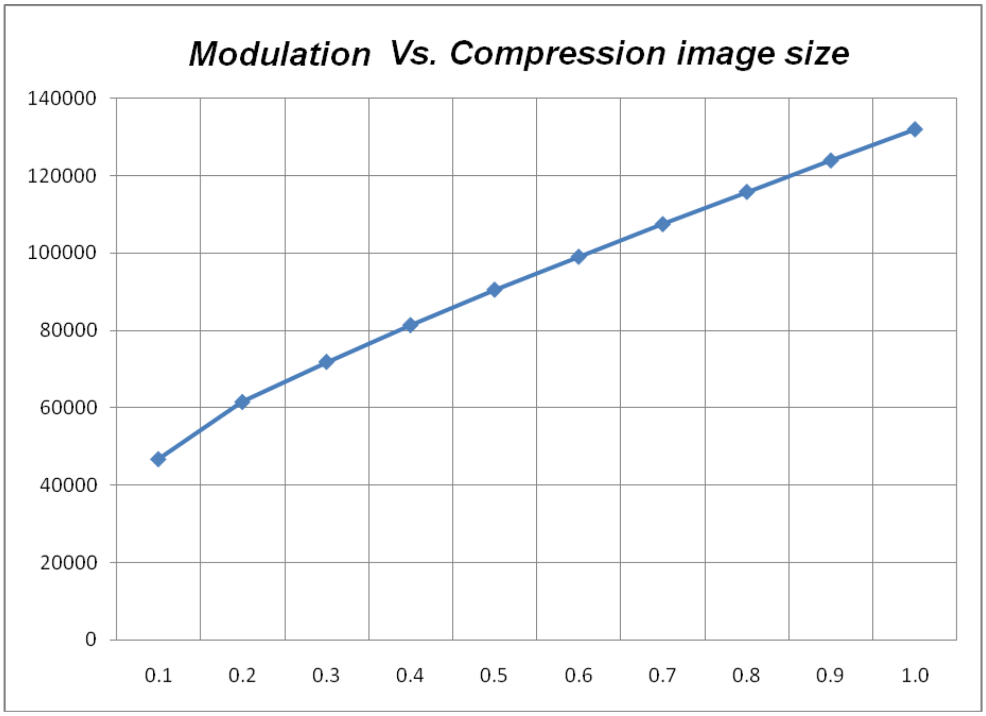


Figure 3. The modulation coefficient behavior with size of the compressed image.

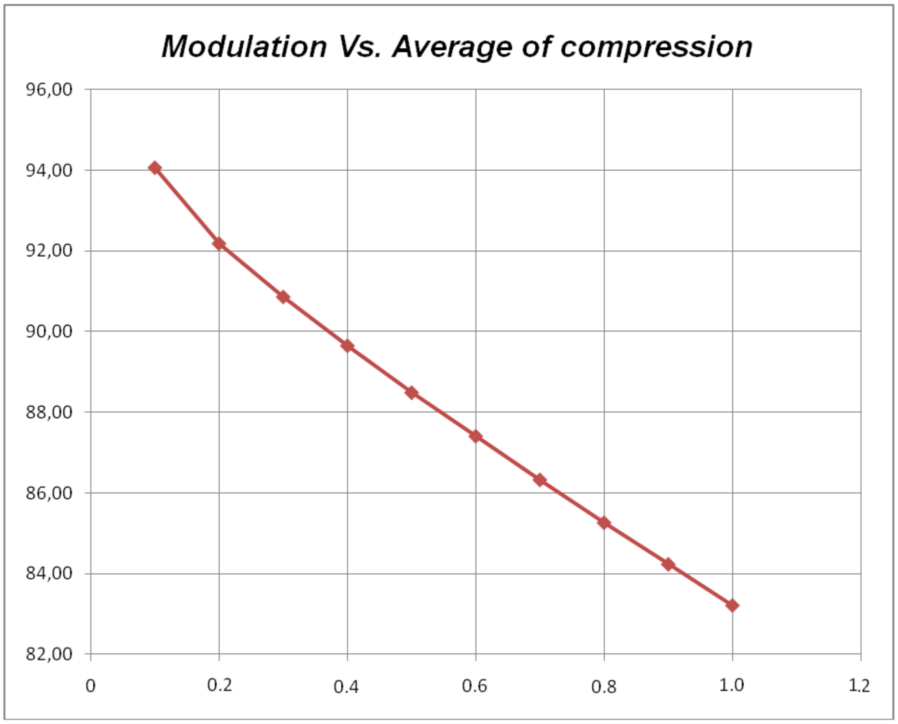
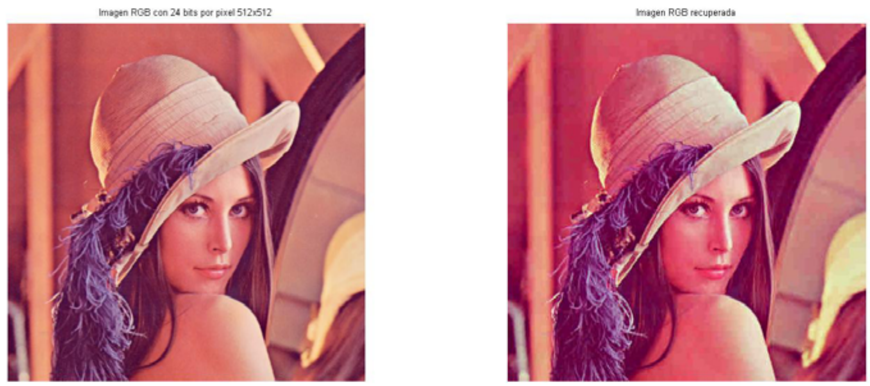


Figure 4. The modulation coefficient versus compression average.

Figure 5 shows the recovery of the original image, and their difference. This difference in reality according to the HVS only to capture in color tones. Differences are not significant for applications of compression video or storage images.



a) b)

Figure 5. a) original image, b) recovered picture

For more information about how the quality factor is used to influence the quantization tables, see the JPEG specification and reference IJG code. [5]

Conclusions

The Modulation coefficient τ of matrix array LH is related to the quality and image compression rate. To compare the differences between the original block and the compressed, is the difference between both image arrays, the average of absolute values, gives a slight idea of lost quality. As these compressed image storage efficiency improvement compared with only in standard JPEG method.
There are maybe other factors that modify the rate of compression of the image inside the JPEG compression scheme which will be discussed in future work.

Sponsors

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