International Standards for Image Compression

Jose Oliver Gil
Universidad Politécnica de Valencia, Spain

Otoniel Mario López Granado
Miguel Hernandez University, Spain

Miguel Onofre Martínez Rach
Miguel Hernandez University, Spain

Pablo Piñol Peral
Miguel Hernandez University, Spain

Carlos Tavares Calafate
Universidad Politécnica de Valencia, Spain

Manuel Perez Malumbres
Miguel Hernandez University, Spain

INTRODUCTION

Only a few decades ago, the human-computer interaction was based on a rudimentary text user interface, a convenient method compared to the punch card era, but too tedious and not very appealing for the nonspecialist, and thereby, not suitable for the mass market. Later on, the multimedia era arrived, with personal computers and other devices having powerful graphic capabilities, plenty of full-coloured pictures shown to the user. Although images made more pleasant the interaction with computers, their use represented a new challenge for electronic engineers; while only a few bytes are needed to represent a text (typically one byte per character in extended ASCII), lots of data must be employed for images that, in a "raw" representation (i.e., uncompressed) for colour images, need as many as three bytes per single *pixel* (picture element, each dot forming an image). Thus, there was a clear urge to reduce the amount of bytes required to encode an image, mainly so as to avoid an excessive increase in both memory consumption and network bandwidth required to store and transmit images, which would limit or prevent their use in practice.

In general, in order to exploit the information system resources in an efficient way when dealing with images, compression is almost mandatory. Fortunately, most images are characterized by highly redundant signals (especially natural and synthetic images), since pixels composing an image present high homogeneity, and this redundancy, often called *spatial redundancy*, can be reduced through a compression process, achieving a more compact representation.

BACKGROUND

The main contribution of this chapter is a brief survey on ISO standards for image coding. This chapter is organised as follows. For continuous-tune still-image lossy compression, the chapter reviews the classic ISO JPEG standard and the newer ISO JPEG 2000, while for lossless compression, the ISO JPEG-LS is presented. In addition, the authors review the JBIG standard, which aims at binary image coding, being widely used for fax transmission.

For continuous tone images (e.g., those from a digital camera), each pixel takes a value in a (nonbinary) range; typically any value in the range $[0..2^8-1]$ for a greyscale image. Actually, for colour images, three bytes per pixel are commonly used (one byte per colour component, red, green, and blue, which is known as RGB colour space), where each pixel represents a colour from up to 2^{24} possibilities. The well-known standard, JPEG (JPEG, 1992), focuses on this type of image. Its sequential mode, widely used throughout the entertainment industry, is based on removing information that is hardly perceived by a human viewer (in particular, high-frequency components are less accurately encoded). Although the decompressed image is not equal to the original one if compared pixel by pixel, the perceptual quality could be nearly the same, provided that no heavy compression is applied. An evolution from this standard is the new JPEG 2000 standard (JPEG 2000, 2000), based on the same ideas, which is more efficient and flexible. However, the higher complexity of JPEG 2000 and the current widespread use

of JPEG make the success of this new version uncertain in the mass market.

This type of image coding process, where recovered data is not the encoded one, is called *lossy compression*. It is important to emphasise that the comparison of lossy encoders cannot be performed based on the final image size alone, but also on its visual quality, in a sort of cost/benefit ratio (usually represented as a rate/distortion curve).

If it is important to recover exactly the original image, for example, for legal reasons in medical imaging or in image editing, *lossless compression* can be done at the cost of lower compression performance (but no quality loss). Although JPEG 2000 has a lossless mode, specific standards, like JPEG-LS (JPEG-LS, 1997), offer better performance. Another famous lossless image encoder is GIF (CompuserveIncorporated, 1987). Frequently used on the Internet, it is intended for 256-colour images that are previously selected in a palette.

Finally, the authors deal with binary images where each pixel can take two different values. These images are typically employed in fax transmission, and are compressed using the JBIG standard (JBIG, 1993).

CONTINUOUS-TONE STILL-IMAGE COMPRESSION

The JPEG Standard

The most widely used algorithm for image coding is defined in the JPEG standard (JPEG, 1992). Introduced in the 1980s, and developed by the Joint Photographic Experts Group (from which the standard is named after), nowadays, it is the most common way of encoding pictures in a wide range of important applications, such as image transmission on the Internet and image storage for digital cameras. This algorithm is able to encode colour images with an average compression rate of 15:1 with good visual quality (Furth, 1995).

The JPEG standard provides four working modes, three of them are lossy and the other one is lossless (Pennebaker & Mitchell, 1992). All the lossy modes employ the two-dimensional discrete cosine transform (2D-DCT) to analyse the spatial-frequency features of the images so as to store with less precision (or even remove) those frequency components least important for a human observer (according to the human visual system). Another important role of the DCT is to achieve high compactness of the information: after the DCT is applied, a substantial part of the image information is concentrated in only a few transform coefficients, mainly the low frequency ones, and thus, it can be represented in an efficient way.

Among its four compression modes, the sequential mode is extensively used, being the simplest and most well known. In this mode, the input image can be a greyscale image or a colour image. Although a digital colour image is commonly represented in the RGB space by an image capture device, it can be stored more efficiently in YCbCr space, in which the luminance component (Y) is represented separately from the blue and red chrominance components (Cb and Cr respectively) (note that the remaining green component, Cr, is not needed because it can be inferred from the Cb, Cr and Y components). Since the human eye is more sensitive to brightness information than to colour, the YCbCr colour representation allows us to reduce the size of the chrominance components without a significant degradation of the perceptual image quality. Thereby, the first step of the JPEG algorithm for colour image coding is a colour space transform from the input colour space to YCbCr, followed by a chrominance downsampling, usually a 4:2:0 subsampling, where the chrominance components are reduced by two in both horizontal and vertical directions (other possible downsampling is 4:2:2, in which only the horizontal direction is reduced by two, or 4:4:4, where there is no subsampling at all).

In the sequential mode, each image component is divided into 8×8 nonoverlapping blocks, and they are compressed and transmitted (or stored) in scan order, from left to right, and from top to bottom, so that the decoder can recover the image sequentially, in the same order as it was encoded. Each block is then processed as follows:

1. The two-dimensional DCT is applied to the entire block (it can be separately applied by using a 1D-DCT, first on the rows and then on the columns). Details on how to compute the DCT can be readily found in the literature (Ghanbari, 2003; Pennebaker & Mitchell, 1992).

2. The transform coefficients are then quantised to reduce information, most of all in high frequency components. This step is responsible for introducing information loss in the encoding process. The quantization process is done by dividing each coefficient by an associated constant value from a quantization matrix, rounding the result obtained to the nearest integer. This matrix is defined in such a manner that the higher frequency a coefficient represents, the higher the denominator (quantization value) becomes, and thereby more information reduction takes place.

3. The DC component of the current block is differentially encoded by using, as a reference, the DC component of the previous block.

4. The rest of the components are scanned in zig-zag order, from lower to higher frequencies, and joint run-length and entropy coding is done. With the run-length coding, a count of zero-values is performed, while entropy coding is a statistical compression method that encodes symbols by using an amount of bits inversely

4 more pages are available in the full version of this document, which may be purchased using the "Add to Cart" button on the publisher's webpage: www.igi-global.com/chapter/international-standards-image-compression/13879

Related Content

Extracting Criminal-Related Events from Arabic Tweets: A Spatio-Temporal Approach
Feriel Abdelkouiand Mohamed-Khireddine Kholladi (2017). *Journal of Information Technology Research (pp. 34-47).*
www.irma-international.org/article/extracting-criminal-related-events-from-arabic-tweets/182711

A Model of Knowledge Management Success
Murray E. Jennexand Lorne Olfman (2009). *Selected Readings on Information Technology Management: Contemporary Issues (pp. 76-93).*
www.irma-international.org/chapter/model-knowledge-management-success/28662

eCRM in a Manufacturing Environment
Aberdeen Leila Bordersand Wesley J. Johnston (2005). *Encyclopedia of Information Science and Technology, First Edition (pp. 966-971).*
www.irma-international.org/chapter/ecrm-manufacturing-environment/14369

Use and Reuse of Collaboration and Communication Technologies in Projects
Manouchehr Tabatabaei (2022). *International Journal of Information Technology Project Management (pp. 1-10).*
www.irma-international.org/article/use-and-reuse-of-collaboration-and-communication-technologies-in-projects/304055

Credit Risk Assessment and Data Mining
André Carlos Ponce de Leon Ferreira de Carvalho, João Manuel Portela Gamaand Teresa Bernarda Ludermir (2009). *Encyclopedia of Information Science and Technology, Second Edition (pp. 800-805).*
www.irma-international.org/chapter/credit-risk-assessment-data-mining/13668