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JPEG2000, the Next Millennium Compression Standard for Still Images

Maryline Charrier
Canon Research
Centre France
mcharrier@crf.canon.fr

Diego Santa Cruz
Ecole Polytechnique
Fédérale de Lausanne
Diego.SantaCruz@epfl.ch

Mathias Larsson
Ericsson Telecom AB
Compression Lab
Mathias.Larsson@etx.ericsson.se

Abstract

With the increasing use of multimedia technologies, image compression requires higher performance as well as new functionality. To address this need in the specific area of still image encoding, a new standard is currently being designed: JPEG2000. We will see in this paper what the exact goals are of this future standard, which applications it addresses and the current standardisation process. Then we will show through the descriptions of two available demonstrations what kind of results are already reachable with the current status of the standard. The first demonstration describes a JAVA implementation of the future standard, details the advantages of such an implementation and compares the performance of JPEG2000 with that of JPEG. The second demonstration describes how JPEG2000 can be used in domains where the transmission bandwidth is very restricted, taking advantages of new functions such as the definition of Regions Of Interest and progressive transmission.

1. Introduction

With the continual expansion of multimedia applications, the needs and requirements of the technologies used in multimedia grow and evolve. Digital imagery is one component of multimedia, and still digital images are a subset of this component. Many compression technologies and associated file formats have been investigated and developed within the last decades, but the most successful technique has without doubt been the JPEG standard, developed within a Working Group of an ISO-IEC Joint Technical Committee (ISO/IEC JTC1/SC29/WG1): the Joint Photographic Expert Group (JPEG). Although the quality of this standard is definitely the main reason of its success (80% of web images are JPEG encoded), the JPEG committee decided three years ago to anticipate the needs and requirements of the second generation imagery applications by defining the need for a new standard: **JPEG2000**.

2. JPEG2000 overview

JPEG2000 is not only intended to provide rate-distortion and subjective image quality performance superior to existing standards [1], but it will also provide functionality that current standards can either not address efficiently or not address at all. For example both lossless and lossy compression, encoding of very large images, progressive transmission by pixel accuracy and by resolution, robustness to the presence of bit-errors and random codestream access. It is interesting to note that JPEG2000 is being designed to address the requirements of very different kinds of applications, e.g. Internet, colour facsimile, printing, scanning, digital photography, remote sensing, mobile applications, medical imagery, digital library and e-commerce.

A Call For Proposal has been issued by ISO/IEC JTC1/SC29/WG1 in March 1997, which has been answered by 22 candidate algorithms. They have all been reviewed and compared both numerically and visually in November 1997, and, from then on, the selection of the best technologies started in order to establish the first Verification Model (VM). This VM is improved gradually by the addition, modification or removal of technologies tested through Core Experiments. As the VM converges towards a stable technology, JPEG2000 will be defined by a Working Draft, then a Committee Draft and should reach its final stage by the end of year 2000: International Standard. At the time this article is written, the algorithm is therefore not yet finalised, however some major tendencies can already be indicated. For example it seems now very likely that JPEG2000 will be based on the Discrete Wavelet Transform. Also, it is possible to demonstrate the advantages and performance of the current VM, which is the goal of the two following example applications.

3. A Java decoder implementation

As is well known, Java(tm) is a relatively new language which is well suited for, but not restricted to, Internet environments, and one that presents many advantages. This language has been chosen to provide an implementation of the decoder of the JPEG2000 VM. This Java decoder is a partial implementation of the VM that includes the most used functions of JPEG2000. At

the time of this writing it is up to date with the latest version of the VM [2].

Java has been chosen for this project because of the advantages that it provides. The most important one is that of platform independence -making the decoder usable on a wide variety of architectures including hand-held devices, embedded devices, computers, etc. In addition it is a dynamic language where new functionality can be incorporated on the fly. This is particularly important for JPEG2000 as it strives to be an open standard. Java is also Web enabled, making it is easy to provide JPEG2000 functionality on the Web, where it is likely to play a major role. The main disadvantage of Java is its execution speed. However new technologies, which are not yet mature, will significantly reduce this penalty (e.g. Just-In-Time, or JIT, and ahead of time compilers, Java chips.

A comparison of JPEG and JPEG2000 has been performed with this Java decoder. For each image one JPEG2000 bitstream was generated at 2 bpp (bits per pixel), and one JPEG file for each bitrate. The PSNRs at various decoding bitrates are reported in Table 1. The images used were colour 'lena' (24 bpp, 512x512) and colour 'bike' (24 bpp, 2048x2560, from the standard JPEG2000 testing suite). One can see that for a similar PSNR quality, JPEG2000 compresses almost twice more than JPEG.

Table 1. Comparison of PSNR (average PSNR between R, G and B) values (dB) between JPEG and JPEG2000 compressed colour images.

Bpp	0.125	0.25	0.5	1.0	2.0
Lena JPEG	24.42	28.02	31.17	33.12	35.15
Lena JPEG2000	28.12	30.61	32.95	35.05	37.35
Bike JPEG	22.60	24.72	28.92	32.16	35.99
Bike JPEG2000	24.85	27.71	31.13	34.59	38.80

The demonstration will show this Java decoder, its functionality and execution speed, as well as PSNR and visual comparisons of JPEG and JPEG2000. The Java decoder and comparisons are available at <http://ltswww.epfl.ch/~neximage/decoder/applets/>

4. An application example for limited bandwidth channels

In JPEG2000 there will be support for different types of progressiveness when compressing the image. It is possible to have progressive by resolution or progressive by accuracy. In the former case the image will increase in size (typically the image grows by a factor 2 both in height and width) up to its original size, when more bits are received. In the progressive by accuracy case, the image starts at its original size but the pixel values are very coarsely approximated. As more bits are received the approximation of the pixel values improves. Thus, the

receiver side will see an image of initially very poor quality that becomes better as more bits are received. Progressiveness is very useful if the channel has limited bandwidth and the transmitted image is large. It also allows the user to stop the transmission when he or she is satisfied with the resolution or quality of the image.

One method of decreasing the transmission time is to use the functionality of what is called Region of Interest (ROI) coding, see [3] [4]. ROI coding means that a part of the image (the ROI) is coded with better quality when compared to the background. ROI coding can roughly be done in two ways: either the image is stored with an ROI or the user can interactively pick the ROI during the transmission [5] and only receive bits for that part of the image.

The demonstration will show progressive transmission of images over a limited bandwidth channel. The channel in the demo will be a GSM connection to the server that stores the image. A laptop is connected to a GSM cellular phone. On the laptop a client program is running. The client calls the server and requests a list of the image files stored on the server. The client then requests one of the compressed images which is then sent to the client progressively. If the client decides to do so, it has the possibility to interactively ask for a ROI.

5. Conclusion

JPEG2000 is only at its early definition stage, but should be completed by the end of the year 2000. However, as demonstrated in this paper and example applications, at its current status, it already outperforms the previous JPEG standard and, in addition, provides new and very useful functions. When JPEG2000 reaches its final status of International Standard, there is no doubt that it will become THE reference compression scheme for still image encoding.

6. References

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