The Future of Digital Watermarking in JPEG 2000

M. A. Suhail
King Fahd University of Petroleum and Minerals
PO Box 1274 Dhahran 31261, Saudi Arabia
suhail@ccse.kfupm.edu.sa

ABSTRACT

The goal of this paper is to put into perspective JPEG 2000 concept a long with watermarking concept. It provides evaluation of JPEG2000 versus JPEG (Joint Photographic Experts Group) standard. The principles behind each algorithm of JPEG 2000 and watermarking are briefly described. An outlook on the future of digital image watermarking within JPEG 2000 is discussed. Views on these issues and up to date research activities in this field will be given. Also, some experimental results are presented.

1. Introduction

JPEG 2000 is issued now to become an International Standard (IS). This paper will give an answer to a common question about the strength of this standard compared with JPEG. An outlook on the future of digital image watermarking within JPEG 2000 will be given. Section 2 introduces an overview of JEPG and JPEG 2000. Also, it compares both standards in terms of technology, performance and applications. Section 3 discuses the concept of digital watermarking. Section 4 provides a look into the future of image coding and data security. Section IV concludes this paper.

2. Joint Photographic Experts Group Standards

This section will introduce some discussion about JPEG and JPEG 2000 standards. JPEG is the most widely used. However, JPEG 2000 is new standards, which will appear in various applications in near future and represent the state-of-the-art in image coding. This section will give an explanation of the principles behind both the algorithms used in each of these two standards.

2.1 JPEG Standard

JPEG is the very well known ISO/ITU-T standard. Several modes are defined in JPEG. Baseline and lossless modes are the most popular ones [1]. It is released in late 1980s

The baseline mode supports lossy coding. The lossless mode is created for lossless coding only. In the baseline mode, the image is subdivided into pixels of size 8x8 (64 pixels). Then, each pixel of this sub-image is level shifted by subtracting the quantity 2^(n-1). The discrete cosine transform (DCT) of each the block is then computed. After that, the block is quantized. The block is reordered using zigzag pattern to form 1-D sequence. The AC coefficients of this 1-D sequence are coded using a variable-length code. The DC coefficient is coded relative to the DC coefficient of the previous sub-image. An excellent background and examples of this are given in [2]. The transformation and normalization process produces a large number of zero-valued coefficients. These zeros which remains after normalization process will be discarded. Then, entropy coded with Huffman coding is done. The quantization step size for each of the 64 DCT coefficients is specified in a quantization table, which remains the same for all blocks. To decompress a JPEG compressed sub-image, the decoder must first recreate the normalized transform coefficients that led to the compressed bit stream. Because a Huffman coded binary sequence is instantaneous and uniquely decodable, this step is easily accomplished in a simple lookup table manner. Any differences between the original and reconstructed sub-image are a result of the lossy nature of the JPEG compression and decompression process [2,3]. Figure 1 shows JPEG block diagram for lossy compression. However, The lossless mode is based on a completely different algorithm. It relies on a predictive scheme which is based on the nearest three causal neighbors and seven different predictors are defined (the same one is used for all samples). The prediction error is entropy coded with Huffman coding. The other modes defined in JPEG provide variants of the previous two basic modes. This is like progressive bit streams and arithmetic entropy coding [2,5].

2.2 JPEG 2000 Standard

JPEG 2000 is also developed by the International Standards Organization (ISO). JPEG 2000 is the new image compression standard. The JPEG-2000 code handles both lossy and lossless compression using

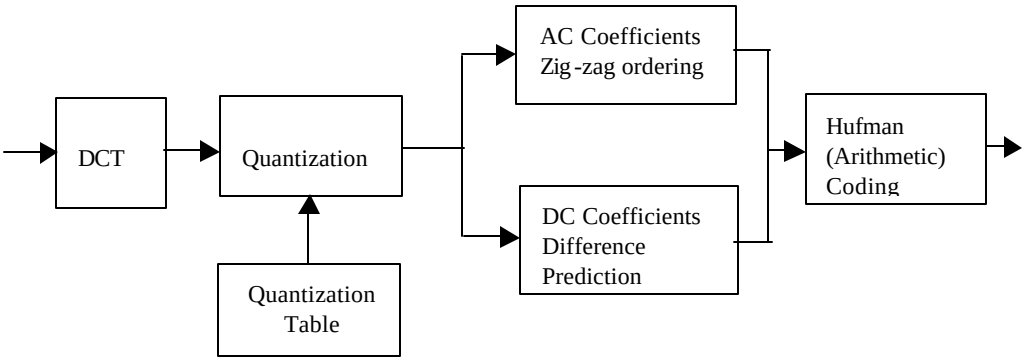

Figure 1: Block diagram of JPEG algorithm (lossy mode encoder)

the same transform-based framework [4]. It is based on the discrete wavelet transform (DWT). DWT provides a number of benefits over the previous JPEG compression techniques, which relies on DCT. DWT are mathematical expressions that encode the image in a continuous stream. So, this will avoid the tendency toward visible artifacts that sometimes result from DCT's division of an image into discrete compression blocks [3-4]. Also, its model relies on scalar quantization, context modeling, and arithmetic coding and post-compression rate allocation. The DWT use in JPEG 2000 is dyadic. It can be performed with a reversible filter (Le Gall (5,3) taps filter 9) [5], which provides for lossless coding. Also, a non-reversible filters (Daubechies (9,7) taps BI-orthogonal one 10) can be used for higher compression to do lossy compression but not lossless. The quantizer follows an embedded dead-zone scalar approach. It is independent for each sub-band. Each sub-band is divided into block (64x64). These sub-bands are entropy coded using context modeling and bit-plane arithmetic coding. The coded data is organized in layers. They are quality levels, using the post-compression rate allocation and output to the code-stream in packets [3]. The basic scheme of JPEG 2000 can be seen in Figure 2. The above was a description part 1 of JPEG 2000 standard, which defines the core system. Part 2 is still in preparation [5].

JPEG 2000 Functionality and Features

JPEG 2000 includes many-advanced feature and supports a number of functionalities. Many of these functionalities are inherent from the algorithm itself [4-6]. These feature and functionalities are:

- High compression ratio
- lossy and lossless compression
- progressive recovery by fidelity or resolution
- Visual (fixed and progressive) coding
- good error resilience
- Arbitrarily shaped region of interest coding.
- Random access to specific regions in an image.
- security
- Multiple component images
- Palletized Images
- It also can support images in width and height from 1 up to (2^32)-1.

JPEG 2000 Applications:

The following are examples of potential application that will benefit directly from JPEG 2000 [7]:

⇒ Document Imaging
⇒ Scanning
⇒ Medical Imaging
⇒ Web Browsing
⇒ Image Archiving
⇒ Digital Library
⇒ Digital Photography
⇒ Color Facsimile
⇒ Internet
⇒ E-Commerce
⇒ Remote Sensing
⇒ Mobile

2.3 Comparison between JPEG and JPEG 2000

In this section, we will give some experiments comparison between JPEG and JPEG 2000. The boat image is compressed at very low bit rates using JPEG, at the same time, the image is compressed to the same degree using the Image Power JPEG2000 encoder [7]. Refer to Figures 3 to 5. At high compression ratios, the images compressed using JPEG degrades significantly. Also, the images compressed using the JPEG 2000 algorithms and at the same compression rates do not suffer from the same degree of degradation as JPEG images. The noise artifacts, such as blockiness, that are clearly evident with JPEG are reduced with JPEG 2000. At very high compression rates the image content is easily recognizable with JPEG2000 but not with JPEG. This shows that JPEG 2000 outperforms JPEG. The compression ratio is 185:1.

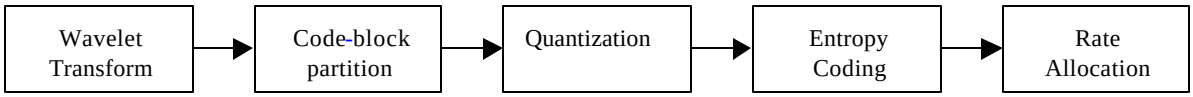

Figure 2: Basic encoding scheme of JPEG2000

3. Watermarking Concept and Techniques

An up-to-date overview of digital watermarking technology is discussed in this section. Many watermarking schemes have been suggested for images and some for audio and video streams. A large number of these schemes address the problems of implementing invisible watermarks. Basic watermarking concepts are discussed in [8,9]. Researchers define a digital watermark as an identification code carrying information (an author's signature, a company logo, etc.) about the copyright owner, the creator of the work, the authorized consumer and so on. It is permanently embedded into digital data for copyright protection and may be used for checking whether the data has been modified. Visible and invisible watermarking are two categories of digital watermarking. The concept of the visible watermark is very simple, it is analogous to stamping a mark on paper. The data is said to be digitally stamped. An example of visible watermarking is seen in television channels when their logo is visibly superimposed in the corner of the screen. Invisible watermarking, on the other hand, is a far more complex concept. It is most often used to identify copyright data, like author, distributor, etc.

3.1 Watermarking Applications and Properties

The two major applications for watermarking are protecting copyrights and authenticating photographs. The main reason for protecting copyrights is to prevent image piracy when the provider distributes the image on the Internet [9]. One method used to authenticate digital images is to embed a digital watermark that breaks or changes as the image is tampered with. This informs the authenticator that the image has been manipulated.

Watermarking techniques that are intended to be widely used must satisfy several requirements. The type of application decides which watermarking technique to be used. However, three requirements have been found to be common to most practical applications. These are robustness, invisibility and delectability. Some of watermarking requirements competes with each other. Also other requirements [8,9] may be significant.

3.2 Digital Watermarking Approaches

First generation watermarking and second generation watermarking are two main classes of watermarking approach [10]. Both approaches can be achieved via spatial or transform techniques such as DCT and DWT. First generation watermarking (1GW) methods have been mainly focused on applying the watermarking on the entire image/video domain. However, this approach is not compatible with novel approaches for still image and video compression. JPEG 2000 and MPEG4/7 standards are the new techniques for image and video compression. They are region- or object-based, as can be seen in the compression process. By contrast, second generation watermarking (2GW) was developed in order to increase the robustness and invisibility and to overcome the 1GW weakn ess. The 2GW takes into account region, boundary and object characteristics. 2GW methods give additional advantages in terms of detection and recovery from geometric attacks [10]. This is compared to first generation. This is happen by exploiting salient region or object features and characteristics of the image. Such watermarking methods may present additional advantages in terms of detection and recovery from geometric attacks, compared to previous approaches [11]. They may be designed so that selective robustness to different classes of attacks is obtained. This will improve watermark flexibility.

4. The Future of Digital Watermarking in JPEG 2000

There was a discussion about how and whether watermarking should form part of the standard during the standardization process of JPEG 2000. The requirements regarding security have been identified in the framework of JPEG2000. However, there has been no in depth clarification nor a harmonized effort to address watermarking issues [12]. It is important to deduce what is really needed to be standardized of watermarking concept in JPEG2000 and to which extent. The initial drafts of the JPEG 2000 standard did not mention the issue of watermarking [4]. However, there is a plan to examine how watermarking might be best applied within the JPEG 2000. D. Santa Cruz and D. Vanrell [13] examined the effect of JPEG 2000 compression on watermarking techniques. Their studies show that the use of a technique, which modifies

coefficients in the wavelet domain out, performs conventional watermarking in the spatial domain. Also, it is easier to integrate into the JPEG 2000 system.

The features of a given watermarking scheme are likely to offer designers an opportunity to integrate watermarking technology into JPEG 2000 at different application such as distributing images on the Internet [12,13]. Also, standardization of digital watermarking will influence the progress in imaging standards of JPEG2000 where the data security will be part of this standard. Therefore the potential is that watermarking technology will be used in conjunction with JPEG 2000. However, at present "it seems unlikely that this will come about directly through the standardization process". [12]

V. Conclusion

The goal of this paper is to discuss the future of digital image watermarking within JPEG 2000. The functionality, performance and features of both JPEG and JPEG 2000 are provided. A comparison between JPEG and JPEG 2000 are given. We also present an up-to-date review of watermarking technology. The paper shows that the DWT based-JPEG 2000 will be the future compression standard. The potential is that watermarking technology will be used in conjunction with JPEG 2000. However, there is an impression that this can not be achieved in the near future because watermarking is not yet standardized.

REFERENCES

[1] http://www.jpeg.org/

[2] Gonalez, R., and Wintz, P. "Digital Image Processing". Addison Wesley, Second edition, 1987.

[3] D. Santa-Cruz and T. Ebrahimi, "A Study of JPEG 2000 Still Image Coding Versus other Standards", *Proceeding of the X European Signal Processing Conference (EUSIPCO)*, V. 2, pp. 673-676, Tampere, Finland, September 5-8, 2000.

[4] ISO/IEC JTC 1/SC 29/WG 1, ISO/IEC FCD 15444-1: "Information technology — JPEG 2000 image coding system: Core coding system, WG 1 N 1646, pp. 1-205, March 2000. Refer to: http://www.jpeg.org/FCD15444-1.htm

[5] D. Santa-Cruz, T. Ebrahimi, J. Askelöf, M. Larsson and C. Christopoulos. "JPEG 2000 still image coding versus other standards", The *Proceeding of the SPIE's 45th annual meeting, Applications of Digital Image Processing XXIII* , V 4115, pp.1-10, San Diego, California, Jul. 30-Aug. 4, 2000.

[6] D. Santa-Cruz and T. Ebrahimi, "An Analytical Study Of JPEG 2000 Functionalities". *Proceeding of the IEEE International Conference on Image Processing (ICIP)*, V 2, pp. 49-52, Vancouver, Canada, September 10-13, 2000.

[7] www.imagepower.com

[8] Busch, Christopher, Wolfgang Funk, and Stephen Wolthusen. "Digital Watermarking: From Concepts to Real-Time Video Applications." IEEE Computer Graphics and Applications, Vol. 19, N0. 1, pp 25-35, .Jan./Feb. 1999.

[9] Hartung F. and M. Kutter. "Multimedia Watermarking Techniques", Proceedings of the IEEE, Vol. 87, No. 7, Jul 1999, pp. 1079-1106.

[10] http://www.tsi.enst.fr/~maitre/tatouage//icip2000.html.

[11] Kutter, M.; Bhattacharjee, S.K.; Ebrahimi, T "Towards second generation watermarking schemes" International Conference on Image Processing, 1999. ICIP 99. pp. 320-323 vol.1 Oct. 1999.

[12] R. Clark, "An introduction to JPEG 2000 and Watermarking", IEE seminar on secure Images & Image Authentication", pp 3/1-3/6, 2000.

[13] http://ltswww.epfl.ch/~ebrahimi/JPEG2000Seminar

Figure 3: Original boat image

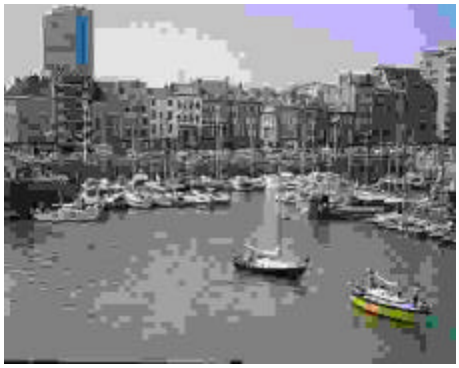

Figure 4: Compressed image using JPEG.

Figure 5: Compressed image using JPEG 2000 with same compression ration as in Figure 4.