適応量子化ウェーブレット変換電子透かしの絵画画像への適用

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A watermarking scheme for images of painting arts based on wavelet transform using adaptive quantization

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Abstract

The digital image watermarking is studied for both copyright protection and content authentication and needed to be better able to survive image processing operations and to be less degradation of picture quality. The characteristics of the watermark scheme is depends on the property of contents. This work deals with the image watermarking of the oil painting arts. The watermarking schemes based on the wavelet transform have many utilization for the digital image contents because it is able to consider the human vision system. This paper reports findings in the experiments of the image watermarking scheme based on wavelet transform for the oil painting arts.

Keywords

Watermarking, Painting art, Digital picture, Picture quality, Discrete wavelet transform

1. Introduction

The explosive growth of digital multimedia techniques and digital network communication has created a processing demand for techniques used for copyright protection and content authentication. Digital watermarking has been proposed as a way to meet these requirements [1]. A digital watermark encodes the owner's license information and embeds it into data. The many requirements for an acceptable technique of watermarking can be seen in ref [2]. Conventional watermarking schemes can be classified into two types, the space domain and the frequency domain. The robustness and the imperceptibility represent the most important characteristics. The several previous researches indicate that they can be more easily obtained in the frequency domain. Discrete wavelet transform (DWT) is popular in many image applications due to the unique feature of multi-resolution representation [3]. In addition, human vision system (HVS) models have been widely used in digital watermarking to minimize the visual effects of the watermark while increasing the strength of watermark [4][5]. Original image is transformed by taking two or three-level DWT. The watermarks are embedded into the image of wavelet coefficients from the second or the third levels. Especially, the quantization steps depend on the property or function of watermarks, and they are adaptive to the image texture feature. This is the most important points in this paper. The utilization of characteristics of human vision leads to control watermark strength adaptively according to the picture contents. The painting arts have many different properties [6] from the natural still images from the viewpoints of HVS and these characteristics clarified by using the wavelet transform watermark schemes are described in the following. Simulation results demonstrate the effectiveness of the watermarking method for the painting arts in terms of quality of the embedded image.

2. The watermark scheme

2.1 The watermark in wavelet domain

The DWT of digital image data has been focused because it was adopted on the image compression technique, JPEG2000 and MPEG4. Since the watermarking is designed for invisible watermarks, invisibility of the watermark in a watermarked image should be take special consideration. HVS theory tells that human eyes are sensitive to the changes in low frequency part of image. Therefore, it is desirable to select the low-high(LH), high-low(HL), high-high(HH) wavelet coefficients for embedding sub-band for the HVS. However, the robustness is decreasing in high frequency components because the high frequency components can be removed thorough the typical image processing such as JPEG compression and noise reduction etc. Figure 1 shows the sub-band structure using two decomposition level.

2.2 The embedding and detection process

The main steps performed in the present watermarking system are summarized in figure 2. Compute the wavelet transform of the host signal (original image data) to get the sub-band coefficients. The original image is decomposed into 7 sub-bands by taking two-level DWT. The quantization step is selected by taking the small range block analysis of the original image data. Those are just classified into two type block; flat/non-flat in the view from HVS. This classification is calculated from the standard deviation for each range block. The small range block size of original image is 4x4 pixels. The robustness depends on the magnitude of quantization step. The quantization step depends on the complexity of the small range block evaluated by the standard deviation. The quantization step for the flat block and non flat block is set to M_1 and M_2, ($M_1 < M_2$) respectively. The robustness suppressed by the reduced embedding strength M_1 is compensated by using the error correct method as a majority-logic. The watermark signal is embedded cyclic every 8x8 block in low-low 2-level (LL2) component of decomposed image. This justly leads to decreasing the amount of embedding bits. The results of decision which block is flat or non-flat are recorded for the detection process.

The detecting process also starts from the DWT decomposition and the quantization step used for the embedding process is detected by the block analysis of the watermarked image as same as embedding process.

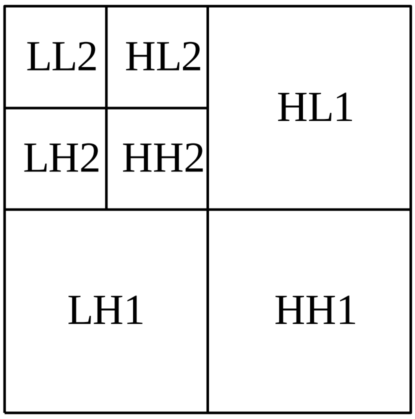

Figure 1. Sub-band decomposition structure.

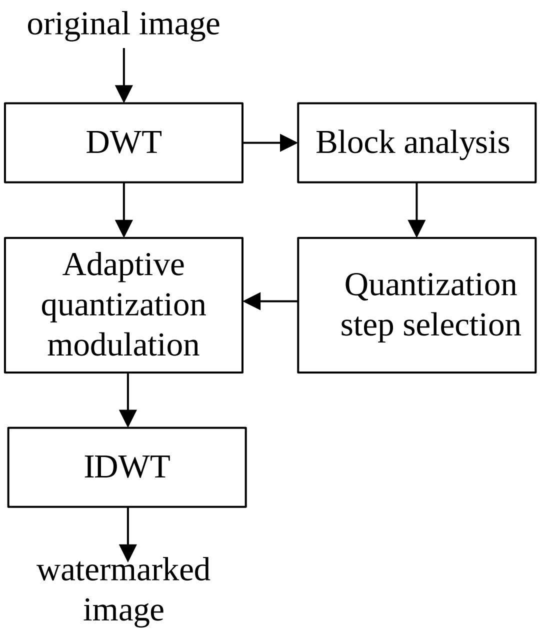

Figure 2. Block diagram of watermark embedding process.

3. The performance analysis

To evaluate the performance, the three kinds of still image are used for the simulation. One is the "Lenna" which is shows in figure 3(a) as known SIDBA standard still image. The other two are the artificial oil painting images of famous self-portraits (figure 3 (b) and (c) are by Picasso and Matisse, respectively. Those painting images have three steps processing for this experiment: resizing for reasonable size following the copyright low in 2009 [7], cropping into same size of Lenna (256x256) and the color changing from full-color to 8bit gray scale. The Lenna includes both the textured area with high frequency components and the large homogeneous areas. On the other hand, the painting images have opposite properties.

In the watermark extraction, the objective measurement, peak signal-to-noise (PSNR) is employed. The results of PSNR between the original image and the watermarked image are shown in figure 4. The parameters are set as same as reference[8]; threshold T=7, M2=7, M1=2～7, Level=2(figure 4(a)), Level=3(figure 4(b)). For all sample images, the same tendency to M1 which is mentioned in the previous work [5] can be reconfirmed in this result.

The robustness for dewatermark especially for JPEG compression have good property in the previous evaluation[5]; more than 80% detection rate for M1 =4～7 in the condition of the JPEG quality factor more than 30% . Hereafter, the picture quality had been evaluated in the condition of M1=4 and 7 for level2 and M1=4 for level3. The evaluation method used in this experiment was the standard subjective method described in Recommendation ITU-R BT.500-7 [8] and also described in the guideline published by Institution of Television Engineers of Japan [9]. Each watermarked picture was shown, after the original picture, to eleven evaluators who rated the quality of the watermarked pictures according to the following scoring rules: score 5 when the watermarks are “imperceptible”, 4 when they are “perceptible but not annoying”, 3 when they are “slightly annoying”, 2 when they are “annoying”. The average of the eleven scores was used as the quality level. Table 1 compares the evaluation results for three sample pictures. From figure 4 and table 1, the following results can be seen:

- The PSNR of Lenna was almost the same as the other two samples when the watermark strength M1 was 7, but the quality of Lenna was degraded. When the watermark strength M1 was 4, the good quality of Lenna was obtained with the PSNR compared with the Matisse. On the other hand, the quality score of Lenna was degraded compared with other two painting samples. The reason seems to be that watermarks are more perceptible in pictures having smooth areas like Lenna than in those having messy areas like the other painting pictures.
- The good quality score were obtained for all pictures when the level was set at 3 but the PSNR was reduced for all ranges of the strength M1 compared with the case of level 2. For example, when the watermark strength M1 was 4, the quality score of Picasso with watermarked with level 3 was 0.09 point higher than that of Picasso watermarked with level 2. This property also can be seen in Lenna but not so slightly, because the messiness increased when the block size was increased. This is due to the results of entropy analysis of the painting art [6].

4. Conclusions

The watermarking schemes depend on the characteristics of the picture contents were studied and especially for the oil painting pictures were treated in the present work. The watermarks are more perceptible in pictures having smooth planes like Lenna than in those having messy planes like the painting pictures. Especially for oil painting, a lot of the messy plane due to the painting touch and the color variation can be created in the whole of picture. From these reasons, the wavelet transform based watermark was adopted because it can deal with the components of the frequencies and the multi-resolution representation (the registrations of the arts contents need high resolution representation). The performances were analyzed with the PSNR and the quality evaluation. In this scheme, the quantization step for the wavelet coefficients means the strength of the watermark. These watermarks are adaptively embedded into different strength depending on the messiness evaluated by the standard deviation of the treated part of the image. This leads to the higher quality of the painting picture rather than the natural still picture. Future work will therefore focus on the analysis from the viewpoints of the correlations between the number of blocks per one flame of painting picture and the entropy of the pixel variations per one flame.

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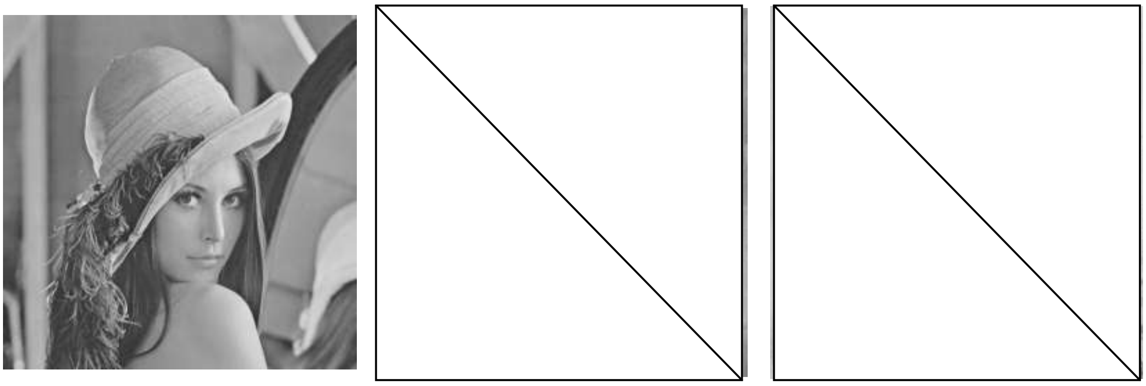
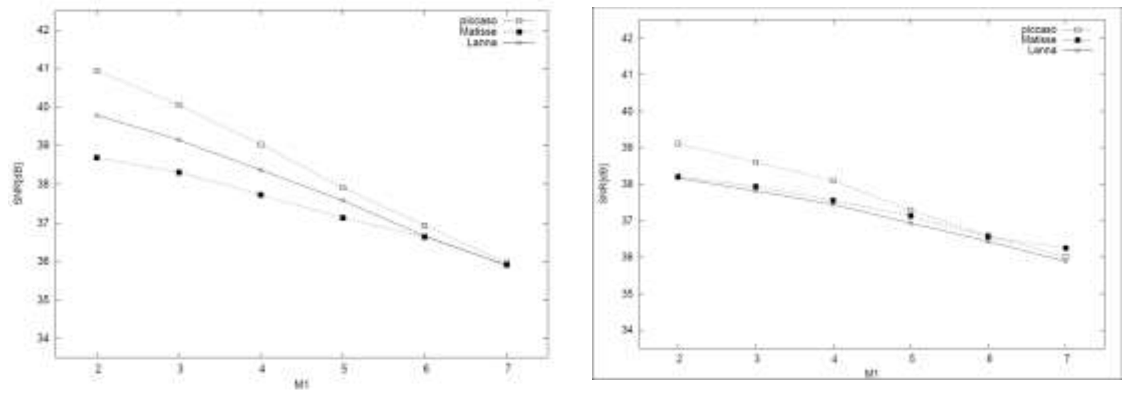


(a)Lenna (b)Picasso (c)Matisse

Figure 3 sample pictures



(a) Level=2 (b) Level=3

Figure 4 PSNR of sample pictures.

Table 1 Quality scores

	Level=2		Level=3
Image	M1=7	M1=4	M1=4
Lenna	3.00	3.45	3.55
Picasso	3.55	4.45	4.64
Matisse	3.97	4.36	4.45