A Digital Watermarking Algorithm Based on EHD Image Feature Analysis

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Abstract. With the development of digital media technology, the problem of digital product copyright protection is becoming more and more serious. The second generation of watermarking technology makes outstanding contributions to solve this problem. This article studies image edge histogram descriptor algorithm to analyze the image feature, then uses JND model which analyses characteristics of human perception to conduct watermarking embedding. The experiment results show that our watermarking algorithm has strong robustness and an acknowledgment.

Keywords: Digital watermarking, MPEG – 7, EHD, Robustness, Imperceptibility.

1 Introduction

With the popularity of digital products, piracy and tort become more and more rampant. Protecting copyright of the works becomes a major problem to digital media workers. Generally speaking, when doing the copyright protection of digital works, the media workers should consider the quality of video at the same time, therefore, digital watermarking technology come into being. In those watermarking algorithms, the imperceptible robust watermark can survive in inevitable signal processing, transmission and other processes. Just as its name implies, this kind of watermarking should not only be robustness but also be imperceptible, however, there is tradeoff between the two characteristics. Improving the robustness of watermark is at the expense of deducing the imperceptibility. In order to balance this tradeoff, there should be an optimal watermark embedding scheme with a perception threshold in practical application [1].

Traditional digital watermarking algorithm mostly use pixels or transform coefficients to embed watermark information, but there are some disadvantages. The watermark can't be embedded into a high human perceptional region. It is advisably to take the important content feature into account. Kutter et al. [2] first put forward the

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concept of the second generation watermark, They used the 2-D Mexican Hat wavelet scale interaction methods to extract image feature, and then did Voronoi division in the center of characteristic region, at last embedded the spread spectrum watermark. As a result the performance of watermark had been greatly improved. Since then, the second generation watermarking schemes have mushroomed-over the past decade. The performance of feature detector is greatly affecting the efficiency of content based watermarking algorithm [3][4]. Harris, SIFT, Harris-Laplace and Harris-Affine feature detector is largely applied in watermarking algorithm.

In this paper we first study MPEG-7 edge histogram descriptor (EHD). Then a novel watermarking algorithm based on EHD image feature analysis is proposed. At the end, experiments indicate the proposed algorithm can improve the performance of content based watermarking system.

2 EHD Image Characteristics Extraction Algorithm

MPEG-7 becomes an international standard In July 2001, which has an official name called "Multimedia Content Description Interface". This standard is mainly used in multimedia content description and information retrieval. As we all know, texture is one of the most basic, easily identifiable characteristics. There are three types of descriptors in MPEG-7 standard to describe the image texture, namely, Homogeneous Texture, Texture Browsing and Edge Histogram, due to the rotating invariance and translation invariance, it can extract automatically by using simple statistical methods, so content based image characteristics extraction often uses histogram method.

Edge histogram descriptor (EHD), firstly proposed by Park D K, et al. [5], this algorithm can help adding up edge features in five directions. Su Jung Yoon et al. [6] proposed a retrieval algorithm which used MPEG-7 edge histogram descriptor to do feature extraction.

The steps for calculating edge histogram descriptor can be summarized as follows:

Step 1: Averagely divide the original image into a non-overlapping 4 × 4 sub-image block.

Step 2: Divide each sub image block into a series of blocks of pixels, as shown in Fig.1.

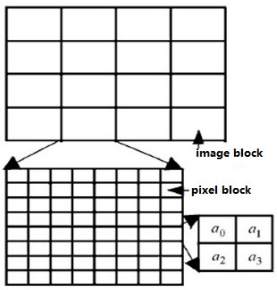


Fig. 1. Image segmentation process (Source: ICCE 2001)

Equation (1) and equation (2) are used to calculate the size of the block pixels, where image_width and image_height respectively represent the width and height of the sub image, in equation (1), the desired_num_block represents the number of blocks for the divided sub picture, whose value is 256 in this experiment [7].

$$x = \sqrt{\frac{\text{image\_width} \times \text{image\_height}}{\text{desired\_num\_block}}} \tag{1}$$

$$\text{block\_size} = \lfloor \frac{x}{2} \rfloor \times 2 \tag{2}$$

Step 3: According to the definition in standard MPEG-7, there are 5 kinds of edge models, namely, horizontal (0 degree), vertical (90 degree), 45 degrees, 135 degrees and non-direction. Each pixel block will continue to be divided into four sub-pixel blocks, as to pixel blocks located in (i, j), we calculate the average pixel value a0 (i, j), a1 (i, j), a2 (i, j), a3 (i, j), then calculate five kinds of the edge mode value by Table 1, edge model is determined by the maximum value of each pixel block. If the maximum value is less than a given threshold, the pixel block will be classified as non-direction. f(k) in Table 1 represents the filter coefficient, the proposed filter coefficients in the MPEG-7 are shown in Fig. 2 [8]:

Table 1. Metric value table of edge model

Edges	Measure values	Edges	Measure values
0°	$\delta_{0°}(i,j) = \lvert \sum_{k=0}^{3} a_k(i,j) f_h(k) \rvert$	90°	$\delta_{90°}(i,j) = \lvert \sum_{k=0}^{3} a_k(i,j) f_v(k) \rvert$
45°	$\delta_{45°}(i,j) = \lvert \sum_{k=0}^{3} a_k(i,j) f_{45}(k) \rvert$	135°	$\delta_{135°}(i,j) = \lvert \sum_{k=0}^{3} a_k(i,j) f_{135}(k) \rvert$
Nd	$\delta_{nd}(i,j) = \lvert \sum_{k=0}^{3} a_k(i,j) f_{nd}(k) \rvert$		

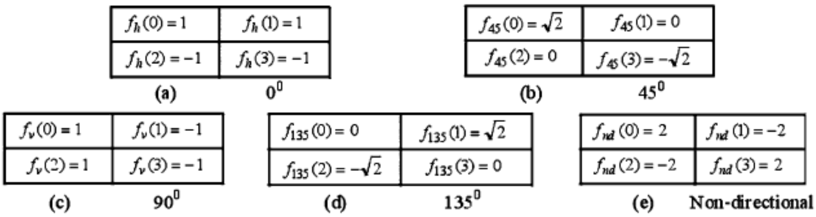


Fig. 2. Filter for edge detection (Source: ICFSKD 2012)

3 EHD-Based Watermark Embedding Scheme

In order to obtain a better transparency of the watermark, we do wavelet decomposition and JND threshold calculation of the image first. This article chooses Barni JND (Just

Noticeable Difference) model [9] which is more consistent with the perceptibility of HVS (human visual system). Wavelet decomposition and reasonable feature extraction of the image make a core part of the watermark embedding model, which is used to guide the watermark embedding.

EHD-based watermark embedding model is shown in Fig 3:

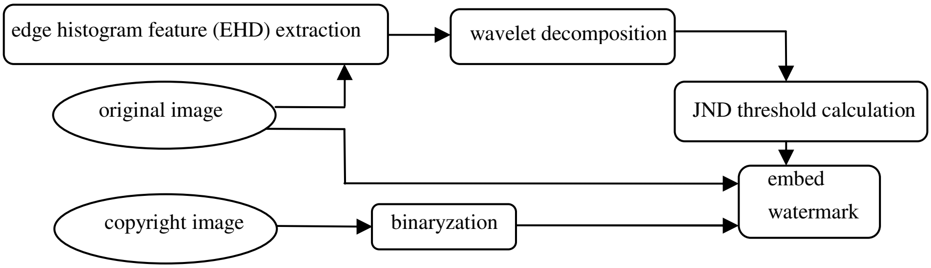
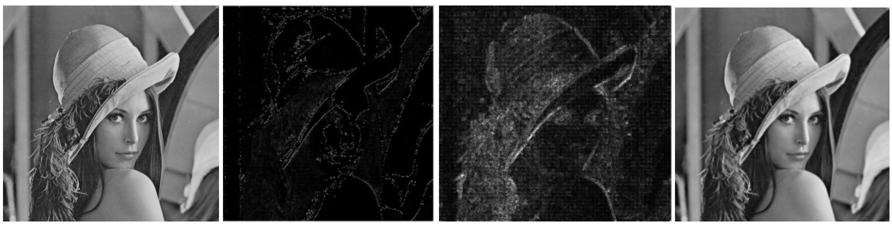


Fig. 3. Embedded process of EHD-based watermark embedding scheme



(a)Original image (b)Image edge feature (c)Embedded location (d)Embedded image

Fig. 4. Original image and processing

Specific watermark embedding steps are as follows. First of all, do content analysis of the original image. We obtain the edges of the image features by the edge histogram feature extraction algorithm. Images are showed in Fig.4 (a),(b). Then, do wavelet decomposition of the obtained image feature information to get the wavelet coefficients, which is to embed copyright information. At last, copyright image is preprocessed into a series of 0, 1 sequences. In fact, it is also the embedded key. Each candidate wavelet coefficient is corresponding to a certain key to decide whether to change the coefficient. Coefficient change means the watermark is embedded in the detail. Our approach is to embed the watermark when the key value is one, not to embed or else. Embedded location and embedded image are showed in Fig.4(c),(d).

The proposed watermark embedding algorithm has an overall consideration in the image information and the human visual perception, using EHD in MPEG-7 to analyze the image feature in order to build a suitable JND model. Extracting is an inverse process of embedding, so we make no more introductions in this article.

4 Experiments and Results

In order to verify the validity of digital image watermarking algorithm in this article, we give the transparency and robustness test as follows, and compare with traditional content watermarking algorithm based on Barni JND Model [9]. The experiment chooses MATLAB software to do a series of simulation test. The original image is Lena of JPEG format, size in 512×512, gray level in 8 bits, shown as Fig.5 (a). The embedded watermarking image is the logo of Communication University of China, whose size is 64×64, shown as Fig.5 (b).

(a) original image (b)watermarking image

Fig. 5. Images used in our experiments

4.1 Imperceptibility Evaluation

PSNR (Peak Signal to Noise Ratio) test of the embedded image is the most common and extensive evaluation for imperceptibility of the watermark. In order to evaluate the imperceptibility, we calculate PSNR of the embedded image. Due to the limited space of this article, we merely give the experimental results of Lena and Peppers image in this paper.

Peak signal-to-noise ratio is defined as follows:

$$\mathrm{PSNR} = 10\lg \frac{m * n * {I_{max}}^2}{\sum_{i=0}^{m-1}\sum_{j=0}^{n-1} ||I(i,j) - J(i,j)||^2} \tag{3}$$

Where $I(i,j)$ represents the original image, $J(i,j)$ is representative of the watermark image, and "m", "n" respectively represents the horizontal and vertical dimensions of image I. Experiment results are showed in table 2:

Table 2. PSNR of embedded image

	proposed algorithm(dB)	algorithm without EHD(dB)
Lena	48.5671	44.9053
Peppers	47.8371	44.4302

As the results shown in the above table, MPEG-7 texture feature extraction has made a great contribution in adjusting JND value, which can improve the imperceptibility of watermark.

4.2 Robustness Evaluation

For robust detection of the algorithm, we present three attacks to watermarked Lena image in this experiment, namely, noise adding, JPEG compression and rotation attack. In order to contrast the performance, this paper adopted a watermarking algorithm which directly use JND model in decomposition of wavelet domain and algorithm with proposed algorithm. We make a contrast in bit error rate as follows.

The experimental results are shown as follows.

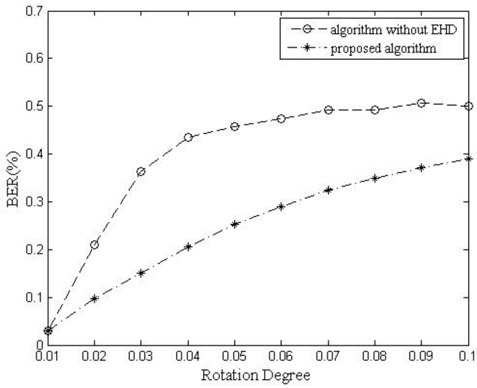


Fig. 6. Robustness versus rotation

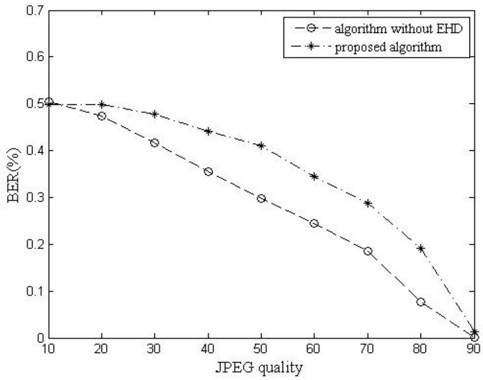


Fig. 7. Robustness versus JPEG compression

From Fig.6, when the image meets with rotation attack, our algorithm has lower bit error rate than the original algorithm. It turned out that in resisting geometric attacks, the algorithm has a good reference. Shown in Fig.7 and Fig.8, there are flaws in resisting noise and JPEG compression. However, nearly 4 dB rise in PSNR makes these defects negligible.

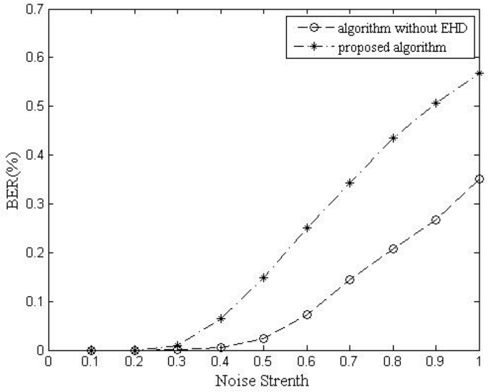


Fig. 8. Robustness versus noise adding

5 Conclusion

Copyright protection watermark has a higher requirement in robustness and invisibility. In order to reconcile the contradiction between them, we have studied the content based second generation watermarking algorithm, proposed a novel content based image watermarking method that calculating EHD of MPEG-7 descriptors to adjust texture masking, to improve the JND model of the algorithm. We achieve a better perceptual model to adjust the watermark embedding strength. Experimental results demonstrate the imperceptibility and the performance against rotation attack have improved. However, the watermark performance assessment system does not have a precision standard. For it is a binary function whose argument are robustness and imperceptibility, there is still a further research in the future.

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