International Journal of Engineering Innovation & Research
Volume 2, Issue 1, ISSN: 2277 – 5668

Digital Watermarking Technique using Discrete Cosine Transform

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***Abstract* — The proliferation of digitized media due to the rapid growth of networked multimedia systems has created an urgent need for copyright enforcement technologies that can protect copyright ownership of multimedia objects. Digital image watermarking is one such technology that has been developed to protect digital images from illegal manipulations. Different watermarking schemes have been suggested for images. This paper proposes a watermarking algorithm based on image segmentation and discrete cosine transform (DCT). The image is first segmented and then for each segment, the image segment is subdivided into pixels blocks of size 8×8 (64pixels), and zigzag reordered. The DCT of the block is then computed. Then, a pseudorandom sequence of real numbers is embedded in the DCT domain of each image segment. Different experiments are conducted to show the performance of the scheme under different types of attacks. The results show that our proposed watermark scheme is robust to common signal distortions, including geometric manipulations.**

***Keywords* - Discrete Cosine Transform (DCT), Digital Watermarking, Design of Watermarking Systems.**

I. Introduction

With the redundancy of the medium as image and voice, digital watermarking technology is to use the digital embedding method to hide the watermarking information into the digital products of image, visible and video. Seen form the field of signal process, the watermarking signal being embedded into carrier is as a feeble signal to add into a strong background. As long as the intensity of watermarking is lower than the contrast restriction of human visible system (HVS) or the apperceive restriction of human audio system (HAS), the water marking signal won't be felt by HVS or HAS. With the characters and important application, digital watermarking technology has been got more and more attention [1][2]. In the future the main development of digital watermarking is like this: copyright protection, pirate tracking, copying protection, image authentication, cover-up communication, classification control of digital watermarking video and so on. And the common characters of digital watermarking are: insensitivity, secrecy, robustness and insurance. According to the different partitions, watermark can be parted in different types like these: significant watermark and the insignificant; the visible and the invisible; the brittle and the steady; the spatial domain watermark and the transformed domain watermark; the blind, the semi blind and the non-blind. One another partition is carrier and there are image watermark, audio watermark, video watermark, text watermark and so on. The current classical algorithm contains spatial domain algorithm and transformed domain algorithm. With the spatial domain algorithm, the embedding and the distilling of watermarking are finished in spatial domain, by amending directly or comparing the gray-level value or color value. The classical spatial domain algorithms including several ways as follow: the least significant bit (LSB) [3], Patchwork method with streak block mapped coding, the method based on district intersecting [4] and so on. Then the main current transformed domain algorithms are spread spectrum, DCT transformation method and DWT transform method.

This paper introduces an algorithm of digital watermarking based on Discrete Cosine Transform (DCT). The watermarking image will be discrete Cosine transformed. Because these DCT modulus contain the low frequency information of watermarking image, as long as these information do not lose or lose little then the watermarking image can be renewed well. This enhances the robustness and concealment.

II. Image Watermarking Requirements and Applications

Each watermarking application has its own specific requirements. Therefore, there is no set of requirements to be met by all watermarking techniques.

A. Perceptual Transparency

In most applications the watermarking algorithm must embed the watermark such that this does not affect the quality of the underlying host data. A watermark-embedding procedure is truly imperceptible if humans cannot distinguish the original data from the data with the inserted watermark. Even the smallest modification in the host data may become apparent, however, when the original data is compared directly with the watermarked data. Since users of watermarked data normally do not have access to the original data, they cannot perform this comparison. Therefore, it may be sufficient that the modifications in the watermarked data go unnoticed as long as the data are not compared with the original data.

B. Robustness

It is desirable that the watermark always remains in the host data, even if the quality of the host data is degraded. Examples of degradations are lossy compression techniques, filtering, re-sampling, digital-analog (D/A) and analog-digital (A/D) conversion.

There are many applications for watermarking including copyright protection, fingerprinting, copy protection, broadcast monitoring, data authentication, indexing, medical safety, and data hiding.

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III. Issues in Design of Watermarking Systems

There are three main issues in the design of a watermarking system:

1) Design of the watermark signal to be added to the host signal. Typically, the watermark signal depends on a key and watermark information.
2) Design of the embedding method itself that incorporates the watermark signal into the host data yielding watermarked data.
3) Design of the corresponding extraction method that recovers the watermark information from the signal mixture using the key and with help of the original or without the original.

The first two issues, watermark signal design and watermark signal embedding, are often regarded as one, and specifically for methods were the embedded watermark are host signal adaptive.

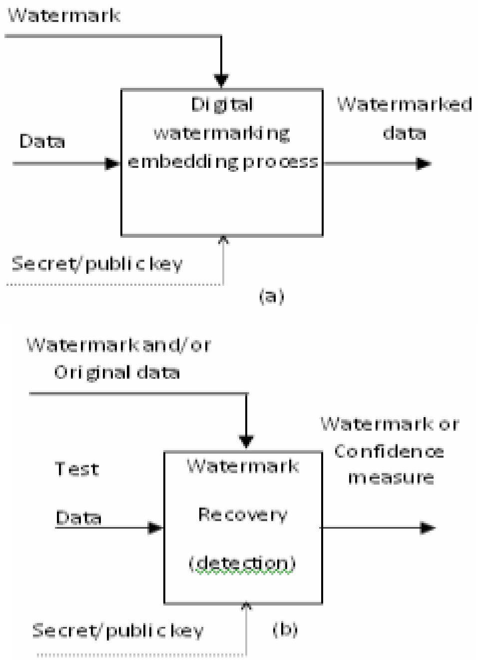

Fig.1. Digital watermarking embedding and detecting systems

Fig.1 illustrates the concept. Fig.1(a) shows the generic watermarking scheme for the embedding process. The input to the scheme is the watermark, the host data, and an optional public or secret key. The host data may, depending on the application, be uncompressed or compressed, however, most proposed methods work on uncompressed data. The watermark can be of any nature, such as numbers, text, or an image. The generic watermark recovery process is depicted in Figure 1(b). Inputs to the scheme are the watermarked data, the secret or public key and, depending on the method, the original data and the original watermark. The output of the watermark recovery process is either the recovered watermark or some kind of confidence measure indicating how likely it is for the given watermark at the input to be present in the data under inspection.

IV. Proposed Discrete Cosine Transform Based Algorithm

Inspired by some of the ideas proposed by Cox et al. [7] and the algorithm in [8], we have constructed our algorithm. In [8] their algorithm rather than embedding the watermark globally in the host image as the Cox algorithm, the original image is first segmented based on Voronoi diagram and the feature extraction points.

Our proposed algorithm is based on image segmentation and discrete cosine transform. The image is first segmented using expectation maximization segmentation algorithm, and then each segment is divided into 8×8 blocks (64 pixels). A zigzag reordering is applied to each block of each segment (see Figure 2).

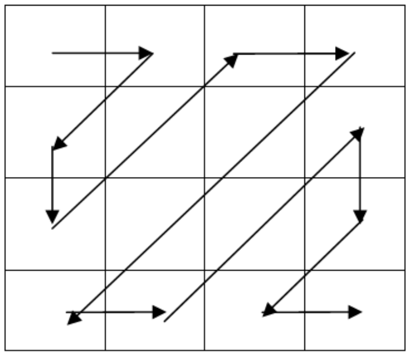

Fig.2. Zigzag Reordering Algorithm

For each 8×8 block in the segments a two dimensional discrete cosine transform (2D-DCT) is applied. The DCT coefficients of each segment are then selected to be modified by the watermark in which we embed a pseudorandom sequence of real numbers in the DCT coefficients of each segment of the host image. This will boost the watermark robustness with affecting the invisibility. The embedding of the watermark is applied to each segment of the image.

To get the watermarked image, the reverse process is applied in which the two-dimensional inverse discrete cosine transform (2D-IDCT) is preformed on each 8×8 block of each segment. Each 8×8 block is reordered using de zigzag reordering which is the inverse of the zigzag reordering mentioned above. Finally the segments are merged together to form the watermarked image.

The two dimensional DCT used in our algorithm is given by

$$C(u,v) = \alpha_u \alpha_v \sum_{x=0}^{M-1} \sum_{y=0}^{N-1} I(x,y) \cos\frac{\pi(2x+1)u}{2M} \cos\frac{\pi(2y+1)v}{2N},$$

for $0 \le u \le M-1$, $0 \le v \le N-1$ and

$$\alpha_u = \begin{cases} 1/\sqrt{M}, & u = 0 \\ \sqrt{2/M}, & 1 \le u \le M-1 \end{cases}$$

$$\alpha_v = \begin{cases} 1/\sqrt{N}, & v = 0 \\ \sqrt{2/N}, & 1 \le v \le N-1 \end{cases}$$

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The two dimensional IDCT is given by

$$f(x,y)=\sum_{u=0}^{M-1}\sum_{v=0}^{N-1}\alpha_u\alpha_v C(u,v)\cos\frac{\pi(2x+1)u}{2M}\cos\frac{\pi(2y+1)v}{2N},$$ for

$0\le x\le M-1$, $0\le y\le N-1$ and α_u, α_v as defined above.

The selected DCT coefficients to be watermarked $C=\{c_1,c_2,...,c_N\}$ are modified by the watermark $W=\{w_1,w_2,...,w_N\}$ which consists of a sequence of randomly generated real numbers. These numbers have a normal distribution with zero mean and unity variance.

The modification (embedding process) is applied according to

$$c_i^{/}=c_i+\alpha\, c_i w_i$$

A value of α = 1 is used in our proposed algorithm, which is shown to be empirical value of α [7],[8]. To tune the watermark energy α can be changed. The length of watermark embedded in each segment is about 1000 divided by the number of segments.

By denoting the original image by I and the watermarked image –possible distorted– by Iw, then a possibly corrupted watermark *W** can be extracted. For extraction process similar procedure as explained above is considered evolving both the original image I and the watermarked image Iw. For evaluating the similarity of watermarks, It is highly unlikely that the extracted watermark *W** will be identical to the original watermark *W*. The similarity between *W* and *W** can be measured by

$$sim\,(W,W^*)=\frac{W\cdot W^*}{\sqrt{W^*\cdot W^*}}$$

as in [7]. It is obvious that the value calculated from equation (7) may change depending on the length of the watermarking vector. A normalized similarity measure can be given by

$$sim_{normalized}\,(W,W^*)=\frac{W\cdot W^*}{\sqrt{W^*\cdot W^*}}\Bigg/\frac{W\cdot W}{\sqrt{W\cdot W}}$$

Other measures are possible, including standard correlation coefficient.

V. Implementation and Results

We have implemented DWT algorithm using MATLAB V.6.5 and found the following results on different images. We have measured PSNR and Elapsed time required for the operation of embedding massage in the images and recovered the massage effectively at receiver.

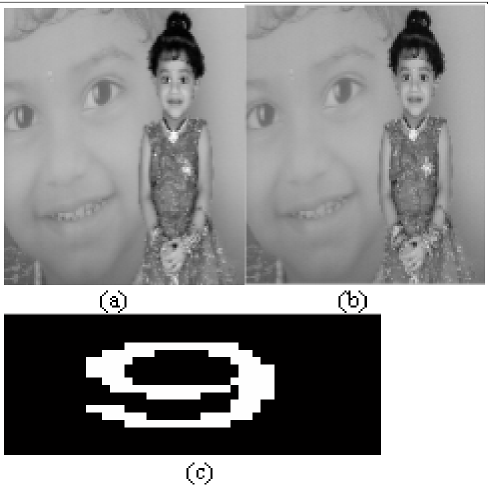

Fig.3. (a) Original Image, (b) Watermarked Image, (c) Recovered Watermark

S. No.	Name of the Figure	PSNR – dB	Elapsed Time – sec
1	Lena.bmp	67.6263	6.5890
2	Circuit.tif	63.3948	2.1030
3	Cameraman.tif	65.4611	1.8920
4	Testpat1.tif	62.6043	2.0030
5	Simulink_logo.tif	54.8567	7.1400
6	Ic.tif	67.4610	1.8430
7	Rice.tif	67.4202	1.8330

Here we have used massage nine file as a water marker which is being recovered from each image but we can see that the recovery depends upon the type of image. Also the PSNR and Elapsed time required for each image is different.

VI. Conclusion

To conclude, we have presented a new robust watermarking scheme. The results of experiments show that this approach is very promising, because it is robust to common image processing distortions. The Discrete Cosine Transform (DCT) has been applied successfully in many in digital image watermarking. In conclusion, in DCT-based digital watermarking applications, combining appropriate transforms with the DCT may have a positive impact on performance of the watermarking system.

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