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Modulation of Watermark Using JND Parameter in DCT Domain

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Abstract— Digital Image watermarking is the process that embeds data called watermark in to multimedia object such that the watermark can be extracted or detected to make an assertion about the object. Watermarking is either "visible" or "invisible".

The growth of high speed computer networks and internets, in particular, explore the means of new business, scientific, entertainment and social opportunities. Ironically the cause for the growth is also of the apprehension use of digital formatted data. The ease with which the digital information can be duplicated and distributed has led to need for effective copyright tools. Various software products have been recently introduced in attempt to address these concerns. It is done by hiding data within digital audio, image and video files. Digital image watermarking is one of the way of data hiding techniques.

Watermarking can be done in spatial and transform domain. The basic problem in watermarking in spatial domain is that the watermark is more fragile i.e., more susceptible to attacks than transform domain. The reason for choosing the transform domain (DCT and DFT is that the characteristics of human vision system(HVS) are better captured by spectral coefficients. For eg. Low frequency coefficients are perceptually significant, which means alterations to those components might cause significant distortion to original image On the other hand, high frequency coefficients are considered insignificant: thus ,processing techniques such as compression tend to remove high frequency coefficients aggressively.

Key words: Copyright protection, digital image watermarking, spatial domain, transform domain, Discrete Cosine Transform(DCT), Discrete Fourier Transform(DFT , Peak Signal to Noise ratio(PSNR), Correlation, Just Noticeable Distortion (JND), SSIM (Structural Similarity)

I. INTRODUCTION

Watermark embedding option can be carried out indifferent transform domain, such as DCT,DFT,DHT (Discrete Hadamard Transform), DWT(Discrete wavelet Transform).
In DCT based approach an algorithm that inserts watermark into the spectral components of image using techniques analogous to spread-spectrum communication. Watermarking in DCT is usually performed on the lower or mid frequencies, as higher frequencies are lost when the image is compressed[1] .The algorithm is to place the watermark into the set of frequency component that are perceptually significant. It has been shown that the watermarks are very hard to detect because they consist of relatively weak noise signals which increases the robustness against the intentional and unintentional attacks .

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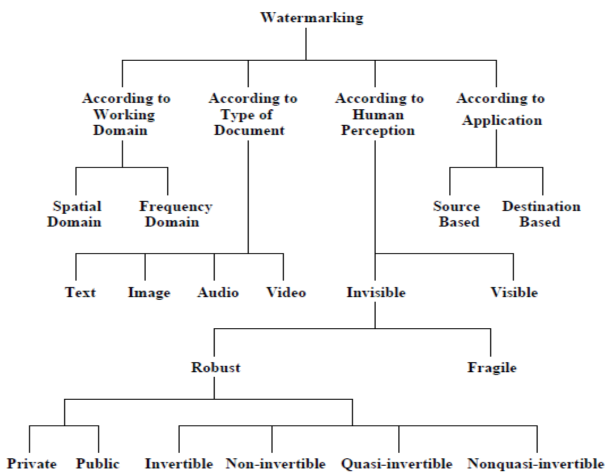
The other algorithm in DCT incorporates JND(Just Noticeable Distortion) to determine the maximum amount watermark signal that can be tolerated at each region in the image without degrading its visual quality. In DWT based approach a wavelet base watermarking algorithm based on principle of multi threshold wavelet codec (MTWC).It searches the significant wavelet coefficients to embed the watermark in order to increase robustness.
In DHT based approach algorithm is used for data embedding. The advantage is that it offers much shorter processing time and easier hardware implementation. Thus it is optimal for real time implementation.
In DFT based approach fourier coefficients have two components-phase and magnitude. Experiments shows that attacks such as geometric rotation , don't modify the phase information of the coefficient. Therefore DFT based algorithm are robust to translation, rotation and scaling attacks[3].Authors also reported that the phase based watermarking are relatively robust to change in image contrast. Modification of DFT magnitude coefficient are much perceptible than phase modification, one would expect that good image compressors would give much higher importance to preserving the DFT phase than the DFT magnitude, rendering the DFT magnitude based watermarking system vulnerable to image compression. All major compression schemes (JPEG,MPEG) preserved the DFT magnitude coefficients as well as preserved the DFT phase.

A. Classification of watermarking techniques

Watermarks and watermarking techniques can be divided into various categories in various ways. The watermark can be applied in spatial domain and frequency domain. It has been observed that frequency domain techniques are more robust than spatial domain techniques. Different type of watermarks are as shown in the figure below.



B. Desired characteristics of visible watermarks

- A visible watermark should be obvious in both color and monochrome images.
- The watermark should spread in large and important area of image in order to prevent its deletion by clipping.
- The watermark should be visible yet must not significantly obscure the image details beneath it.
- The watermark must be difficult to remove. Removing watermark should be more costly and labour intensive than purchasing the image from the owner. The watermark can be applied automatically with little human intervention and labour.

Watermarking is the process that embeds data called watermark or digital signature or tag or label in to multimedia object. The object may be image, audio or video.

Any watermarking scheme or algorithm consist of three parts 1. Watermark 2. The encoder (insertion algorithm) 3.The decoder and comparator(verification algorithm)

Encoding and Decoding Process Encoding process

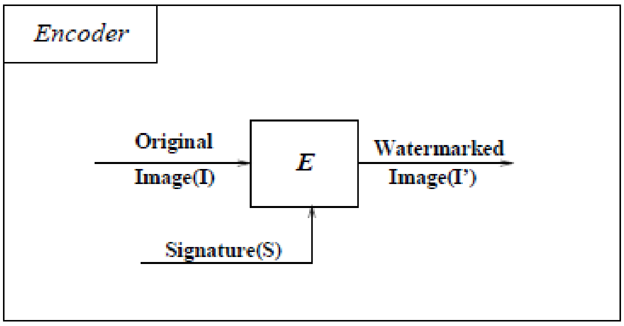


Figure 2

If image I, signature S = S1, S2….. and watermark image is $\hat{I}$. E is an encoder function that takes on image I and signature S that generates new image which I is called as water marked image $\hat{I}$

Mathematically **E(I,S) = $\hat{I}$ [1].**

Decoding Process

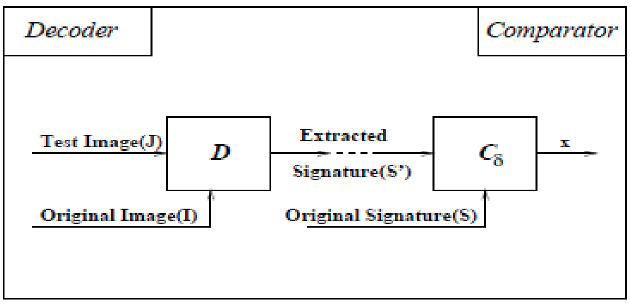


Figure 3

A decoder function D takes an image J (J can be watermarked or unwatermarked) whose ownership is to be determined and recovers the signature S` from the image. The additional image I can also be included which is often the original and unwatermarked version of J.

Mathematically **D (J, I) = S`**

II. IMAGE WATERMARKING IN DCT

There are plenty of image watermarking techniques, algorithm available in the literature. In image watermarking DCT involves dividing the host image into different blocks. Then DCT of each block is evaluated. Each block is then assigned different Alpha and Beta values.

$$X_{ij} = \alpha X_{ij} + \beta W_{ij} \qquad (1)$$

Where Xij is DCT coefficient of original image and Wij are DCT coefficients of watermark image. The watermark is insert into spectral components of the image using technique to spread spectrum communication. The argument is that the order mark must be inserted in the perceptually significant components of a signal if it is to be robust to common signal distortation and malicious attacks. However the modification of this components may lead to perceptual degradation of the signal.

III. PROPOSED METHOD

This paper proposes a robust and transparent scheme of watermarking [2] that exploits the 'human visual system (HVS). Sensitivity to frequency along with local image characteristics obtained from spatial domain.

As a practical and novel application of watermarking, a digital watermarking-based image quality evaluation method that can accurately estimate image quality in terms of the classical objective metrics, such as peak signal-to-noise ratio (PSNR). At the same time care is taken to prevent the unauthorized use of images commercially. In visible watermarking, a secondary image is embedded in primary image such that watermark is intentionally perceptible to observer. The quality of watermarked image is adjusted using scaling factor. the □n and □n values are found out using a mathematical model developed by exploiting the texture sensitivity of the human visual system (HVS). This ensures that the perceptual quality of the image is better preserved. In this proposed project, we describe a visible marking scheme that is applied in to the host image in DCT domain. Using MATLAB we are developing different function for each block and its mathematical model will be further developed.

A. Evaluation Of Watermark Extracted Image and Watermark

The quality of the watermark extracted image is verified using the Peak Signal to Noise Ratio .It should be always greater than one.

The verification of water mark is done by using correlation method .For perfect match it should be one.

PSNR: The Peak Signal to Noise Ratio is utilized to evaluate image quality. To check the visual distortion of watermark image we calculate PSNR

$$PSNR = 20\log_{10}\left(\frac{255}{\sqrt{MSE}}\right) \qquad (1)$$

Correlation: The correlation factor measures the similarity between the original watermark and the extracted watermark from the image(robustness).The correlation factor may take the values between 0(random relationship) to 1 (perfect linear relationship)

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Formula: (2)

$$X = \sum_{i=1}^{N} (W_i * B_i) \quad \textbf{(3)}$$

Where: - W = watermarked image.

B = watermark image.

B. Algorithm

$$f(x,y) = \bigcup_{n=0}^{N-1} B_n = \bigcup_{n=0}^{N-1} f_n\ (i,j), Where\ 0 \le i,j < 8$$

Below is the algorithm for this approach –

- The original image I and watermark image W each are 256*256 gray scale images.

$$a_p = \begin{cases} \frac{1}{\sqrt{M}} & p = 0 \\ \sqrt{\frac{2}{M}} & 1 \le p \le M-1 \end{cases}$$

- The host i.e. original image I (to be watermarked) and the watermark image W are divided into blocks of size 8x8.
- The DCT coefficients for each block of the host image are found out. These are 64 coefficients.
- For each block of the host image I, Texture, Edge, Luminance and Corner information is computed.
- After obtaining these value JND mask is generated using formula:

$$J_I = M_T - (½)*(M_E + M_c) \quad \textbf{(4)}$$

- The human vision system is more sensitive to the changes in intensity in the mid-gray region.
- Hence a correction to the initial JND parameter value is introduced and the final JND parameter value for each block is calculated as:
- JF = JI + (128 –ML) (5)
- The DCT of watermark image blocks are found out.
- For every block, all DCT coefficients of the host image I are modified as below
- Wmk (i.j) = (1-JND)*Hk (i.j) + JND* Wk (i.j) (6)
- The IDCT of modified coefficients gives the watermarked image.

Let f(x,y) be the original grey scale cover image .This image is segmented into non overlapping blocks of size 8X8.This is denoted as Bk, n=0,1,2……N-1. (7)

Where M and N are the rows and column size of A respectively[2]. The formula to calculate the DCT in MATLAB is given by,

$$B_{pq} = a_p a_q \sum_{p=0}^{M-1} \sum_{q=0}^{N-1} A_{mn} \left(\cos\frac{\pi(2m+1)p}{2M} \times \cos\frac{\pi(2n+1)q}{2N} \right) \quad (8)$$

The formula to calculate inverse DCT in MATLAB is given by[2]:

$$A_{mn} = \sum_{p=0}^{M-1} \sum_{q=0}^{N-1} \alpha_p \alpha_q\ B_{pq} \cos\frac{\pi(2m+1)p}{2M} \times \cos\frac{\pi(2n+1)q}{2N}$$

$$\alpha_p = \begin{cases} \frac{1}{\sqrt{M}} & p = 0 \\ \sqrt{\frac{2}{M}} & 1 \le p \le M-1 \end{cases}$$

$$\alpha_q = \begin{cases} \frac{1}{\sqrt{N}} & q = 0 \\ \sqrt{\frac{2}{N}} & 1 \le q \le N-1 \end{cases} \quad \textbf{(9)}$$

IV.RESULT

Our experiments on the proposed content based watermarking algorithm are based on gray scale images. The cover image used is "Lena" and watermark used is "Rice" the scaling factor is set according to content and quality of watermark image. The greater the scaling factor better is the watermark detection however reducing the overall quality of image.

Here host image and watermark image both are of size 256 x 256 and the Peak Signal to Noise Ratio is found out to be "21.5818". The correlation factor gives the relationship between original watermark and extracted watermark. For random relationship it "0" and for linear relationship is "1". We found the correlation to be "1" as the image is not expose to any attacks, such as compression, noise, filtering etc.

PSNR = 21.5818,

Correlation = 1.

V. CONCLUSION

Our scheme implements an algorithm that embeds image as a watermark in DCT domain and calculates the PSNR of watermark extracted image and the correlation of original watermark extracted watermark.

A good balance between robustness and imperceptibility has been achieve using the scheme as observers can evaluate the quality of watermarked image as well as the recovered watermark to be good.

Further research can be done in implementing the watermarking for color images and video watermarking.

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The watermarked image is further exposed to various attacks like salt and pepper, jpeg compression, median filter, rotation, guassian filter, log filter, rotation etc. The quality of image is evaluated on the basis of PSNR and SSIM factor.The quality of watermark is evaluated on the basis of correlation factor as shown below

Sr. No.	Attack	PSNR	Correlation	SSIM
1.	Salt and pepper	33.44	0.99	0.99
2.	Guassion noise	26.6	0.1	0.06
3.	Compression	29.38	0.19	0.13
4.	Median filter	29.37	0.31	0.24
5.	Log Filter	26.92	0.23	0.16
6.	Roation	9.14	0.01	0.00

VI. FUTURE SCOPE

Although watermarking schemes based on DCT are robust to number of attacks, it fail in presence of geometric attacks such as rotation, scaling and translation[4]. The DFT of a real image is conjugate symmetric, resulting in symmetric DFT spectrum. Because of this property, the popularity of DFT based watermarking has increased in the last few years. In future we focus on embedding the watermark in DFT domain. The image can be exposed attacks as noise, compression, cropping etc and see the result of PSNR and correlation and SSIM.

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