# Incorporating HVS Parameter into the Transform-based Watermarking

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*Abstract:* - In this paper, transform-based watermarking scheme based on human visual system is proposed. Human visual parameters are useful to ensure the imperceptibility of watermark image. Not only human visual parameters, such as contrast sensitivity, texture degree but also statistical characteristics are involved to select the optimal coefficients region. The performance of proposed algorithm is evaluated by the experiments of imperceptibility and correctness of watermark. According to some experimental results, contrast sensitivity function is superior in smooth image. On the other hand, statistical characteristics provide good results in rough images. Consequently, how to select the parameters considering image attribute is key problem in effective watermarking.

*Key-Words:* - Watermark, HVS, DCT

## 1 Introduction

The information types of multimedia productions are digital form, which is easy to be stolen by way of transmitting on networks. Therefore, the copyright protection and enforcement of intellectual property rights for digital media has become an important issue. One of the faithful solutions and the most popular method is a digital watermark technology which is the practice of hiding a message into the digital media such as audio, image and video. Since the late 1990s, there has been a rapid increase in the number of digital watermarking algorithms published[1][2]. Applications of digital watermarking include owner identification, authentication, proof of ownership and copy control. Watermarking strategies divided into two major categories: transform-domain and spatial-domain approach. Transform-domain watermarking methods, also called multiplicative watermarks, such as Fourier transform, discrete cosine transform (DCT), discrete wavelet transform (DWT). The watermark is hidden in the middle or lower frequency band is more liable to be suppressed by compression. Therefore, for watermarking, how to select the best frequency band of the image is more important than any other procedures [3] [4].

This paper presents a method of incorporating human visual system (HVS) parameters into the transform-based watermarking. The main goal of this method is to utilize a HVS in order to analyze a performance of watermarking with respect to the image attributes. Further more, statistic parameters are also involved to generate an effective watermarking.

## 2 Relations between HVS and Transform Domain Coefficients

There are many requirements for a good-designed watermark such as robustness, imperceptibility, unambiguousness etc. Among all types of watermarks, two most common requirements for effective watermarking are required. It should be perceptually invisible, which means the watermark is not visible under typical viewing conditions. It should also be robust to common signal processing and intentional attacks. Spatial domain watermarking which process directly to the location and luminance of the image pixel is one of the fundamental methods in the beginning of digital watermarking researches. This method has the disadvantage that they tend not to be robust congenitally in spite of having simple and easy for implementation. In general, transform domain based approached are superior to that of spatial domain in preserving contents fidelity and robustness under attacks. In this scheme, three main steps should be specified: image transformation, watermark embedding, and watermark recovery.

The HVS has identified by several phenomena which is related with spatial resolution, intensity resolution, and intensity sensitivity and so on. Let us discuss in more detail the characteristics of these visual properties of HVS which can be described in many terms. Contrast sensitivity means variance or difference of the pixel's brightness. The more contrast property the coefficients region has, the stronger the embedded watermark could be. Contrast sensitivity $Cs$ can be expressed as

$$Cs = \frac{I_{\max} - I_{\min}}{I_{\max} + I_{\min}} \quad (1)$$

Where, $I_{max}$ and $I_{min}$ denotes the max. and min. brightness for selected region respectively.

The variance of the pixels in sub-image influence the texture, and texture sensitivity means the perceptibility of sine wave. The more complex the background is, the larger the watermark could be. Therefore, texture sensitivity $Ts$ is calculated by DCT coefficients of an image. Namely, quantization results of the DCT coefficients are the same as integer and finally, $Ts$ can be expressed by

$$Ts = \sum \{rnd[X_k(x,y)/Q(x,y)]\} \quad (2)$$

Where, $X_k(x,y)$ means the $k'th$ DCT coefficients block and $(x,y)$ refers to the location.

Entropy means the mathematical expectation of the information with respect to the occurrence of the events. When it comes to increase the entropy, watermarking region can be extended. Entropy sensitivity $Es$ can be defined as

$$Es = \sum_{x,y=0}^{7} p_k(x,y) \log \frac{1}{p_k(x,y)} \quad (3)$$

$$p(x,y) = \frac{X_k(x,y)}{\sum_{x,y=0}^{7} X_k(x,y)} \quad (4)$$

Not only these HVS but also statistical parameters such as average, standard deviation are also utilized to generate an effective watermarking. These functions are given by

$$Av_k = \left\{ \sum_{x,y=0}^{7} X_k(x,y) \right\} / \, size\,(X_k) \quad (5)$$

$$Std_k = \sqrt{\left\{ \sum_{x,y=0}^{7} (a(x,y) - Av_k)^2 \right\}} / \, size\,(X_k) \quad (6)$$

## 3 System simulation and review

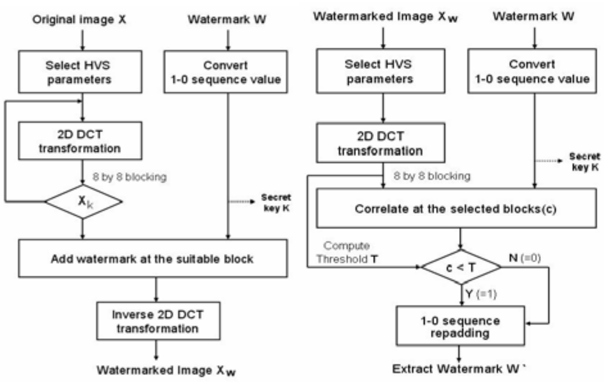
In the transform-based, embedding the watermark is similar to the multiplicative embedding rule, which can be expressed by

$$O_i^{'} = O_i \cdot (1 + \beta W_i) \quad (7)$$

Where, $O'$ and $O$ imply the watermarked material and the original counterpart, respectively, $W$ denotes the watermark, $i$ represents the positions to be embedded, and $\beta$ is the gain factor. For the watermark with length L, $i \in [0, L-1]$. In order to detect or verify the watermark pattern, a correlate function is often used for full extraction of the watermark. The correlation $(R_{O'',W})$ between the possibly attacked image $O''$ and the watermark $W$ can be calculated by

$$R_{O'',W} = \frac{1}{L} \sum_{i=0}^{L-1} O_i^{''} \cdot W_i \quad (8)$$

The main issue, in this approach, is to incorporate the HVS with the transform domain watermarking algorithm so as to select the optimal parameters due to the characteristics of original image. Watermarking embedding and extraction process are shown in Fig. 1.




(a) (b)

Fig. 2 Proposed watermark scheme: (a) watermark embedding, (b) watermark extraction

The main issues of watermarking schemes focus on how to reserve imperceptibility as well as robustness by utilizing HVS [5]. One important

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feature of our algorithm is it's capability to adaptively calculate the watermark strength and the number of region to be watermarked. We have already reported some results based on the fuzzy inference and the DWT domain [6]. In our approach, two main stages including DCT pre-processing and fuzzy inference can be stated as follows:

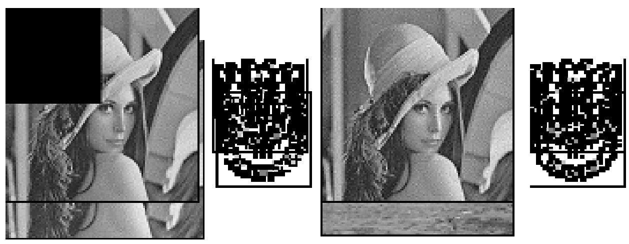
*Step 1*. Definition:
DCTc: DCT coefficients, GDCTc: Group of DCTc
MVoDCTc: Maximum variance of DCTc, FIS: Fuzzy inference system
Sf: Similarity factor for FIS, Sw: Strong watermark, Ww: Weak watermark
/* stage for obtaining DCTc */
*Step 2.* Preprocessing
*100 :* Perform the 2D DCT
*Step 3*. *while* image block is not empty *repeat*
*Step 4*. Grouping DCTc into 3-level
Calculating MVoDCTc
*Step 5*. *if* MVoDCTc is larger *than* TH
*goto 100*
/* stage for fuzzy inference */
*Step 6*. *Repeat* step 7 - step 10.
*Step 7*. *for* each value of GDCTc applying FIS
given fuzzy association map
/* stage for embedding watermark */
*Step 8*. Find the defuzzification value.
*Step 9*. Find the Sf
*Step 10*. *if* Sf >*then* embedding a Sw
*else* Ww
*Step 11*. End of algorithm.

# 4 Conclusion

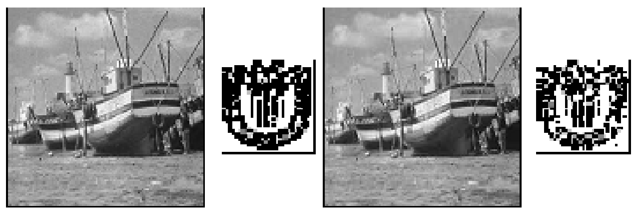
In order to test the proposed scheme, the watermark image of size 32*32 is generated. Several common numerical processing and geometric distortion were applied with respect the gray scale standard images. To evaluate the imperceptibility of the watermarked image, the peak signal-to-noise ratio (PSNR) is used and, a correlation function is also used for full extraction of the watermark. Experimental results showed that the proposed approach is robust to several signal processing schemes, including JPEG compression, Gaussian noise, histogram equalization and geometric cropping. Fig. 2 shows the response with our method in various attacks. In table 1, meaningful results are illustrated with respect to some HVS parameters, and to some attacks. Finally, regarding the future research, it will be devoted to investigate the trade-off point which is the best case of relations between HVS and various attacks.

Table 1. Experimental results with respect to standard images.

| Attack / HVS | Lena Image | | |
|---|---|---|---|
| | Loss 1/4 of image | JPEG Q = 50 | Gauss. noise mean = 0 Var.= 0.01 |
| Contrast | 0.972 | 0.890 | 0.975 |
| Texture | 0.963 | 0876 | 0.968 |
| Entropy | 0.957 | 0.869 | 0.917 |
| Std. | 0.968 | 0.884 | 0.924 |
| | Boat Image | | |
| | Loss 1/4 of image | JPEG Q = 50 | Gauss. noise mean = 0 Var.= 0.01 |
| Contrast | 0.732 | 0.894 | 0.962 |
| Texture | 0.966 | 0.872 | 0.948 |
| Entropy | 0.970 | 0.861 | 0.908 |
| Std. | 0.982 | 0.911 | 0.975 |



(a) (b)
(c) (d)



(e) (f)

Fig. 2 Extracted the watermarks and the images including attacks: (a),(d) cropping, (b),(e) Gaussian noise, (c),(f) JPEG compression (Q=50)

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