A VISUAL MODEL WEIGHTED COSINE TRANSFORM FOR HIDING WATERMARK IN IMAGES*

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Abstract Watermarking is a technique for labeling digital pictures by hiding secret information into images. Watermark embedding is a method to discourage unauthorized copying and identify the owner or distributor of digital data. In this paper, a new method is proposed. The watermark is processed as a visually recognizable pattern—binary image, which includes more information than the traditional symbol or ID number and is “extracted” instead of only “detected” to characterize the owner. The watermark is hidden in the host image by selectively modifying the middle-frequency part of the host image in conjunction with the human visual system (HVS) and the image discrete cosine transform (DCT). The experimental results show that this method can survive image cropping and image compression, and get better results, this is also a prospective method.

Key words Digital watermark; DCT transform; HVS model; Radial frequency

I. Introduction

With the increase of digital media, data distribution is becoming faster, easier, and requires less effort to make exact copies. Digital watermarking has been proposed as a way to claim the ownership of the source and discourage unauthorized copying and distribution. To achieve the maximum protection, the embedded watermark should be Imperceptible, Undeletable, Statistically undetectable, Robustness and Unambiguous[1].

In most previous works, the watermark is considered as a symbol or ID number that comprises a sequence of bits, and can only be “detected” by employing the “detecting theory”[1]. But in our method, the watermark is processed as a visually recognizable pattern—binary image, which includes more information and is “extracted” instead of only “detected” to characterize the owner. And there are also other references process the watermark as a binary image[2].

In most natural images, the energy is concentrated on the lower frequency range, it is very sensitive for the change in this range. On the other hand, the higher frequency components are easy to lose through lossy data compression and other operations, so it is necessary to find a good trade-off method between the robustness of the watermarking and the quality of the watermarked image and the computational cost. Because human is the final observer of the image, application of various models of the human vision system (HVS) has in fact been empirically found to improve image quality.

In this paper, a new method is proposed to hide watermark in images by selectively

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modifying the middle-frequency part of the host image in conjunction with HVS and the image cosine transform (DCT). The experimental results show that this method can survive image cropping and image compression, and get better results.

II. HVS Model and Middle-Frequency DCT Coefficients

1. HVS model

Various HVS models have been proposed in many literatures [3,4]. In this paper the HVS model can be represented by the following equation:

\[ H(\omega) = (a + b\omega) \exp(-c\omega) \]  

(1)

Where \( \omega \) is the radial frequency in cycles per degree of visual angle subtended, \( a, b, \) and \( c \) are constants that determine the shape of the HVS curve. For a normalized curve, these constants are roughly related to the peak frequency \( \omega_{max} \), when \( \omega_{max} = 3 \text{ cycle/degree} \), the HVS curve can be represented by the following function:

\[ H(\omega) = (0.2 + 0.45\omega) \exp(-0.18\omega) \]  

(2)

It is a good working representation of the HVS. But this approach can not be used to combine with the image DCT directly, so in Ref. [3], a function \(|A(\omega)|\) was proposed, the representation is

\[ |A(\omega)| = [1/4 + (\ln(2\pi\omega/\alpha + (4\pi^2\omega^2/\alpha^2 + 1)^{1/2}))^2/\pi^2]^{1/2} \]  

(3)

for \( \alpha = 11.636 \text{ degree}^{-1} \), so the vision corresponding function \( H'(\omega) \) can be known as the following equation when dealing with image DCT instead of image discrete Fourier transform (DFT):

\[ H'(\omega) = H(\omega)|A(\omega)| = \begin{cases} 0.05 \exp(0.554\omega), & \text{when} \ \omega < 7 \\ 0.05 \exp[-9(lg\omega - lg9)^2.3], & \text{when} \ \omega \geq 7 \end{cases} \]  

(4)

The shape of \( H'(\omega) \) is shown in Fig.1:

![Fig.1 The shape of the function \( H'(\omega) \)]