Perceptual Wavelet Watermarking and Extraction of Secret Image by Singular Value Decomposition and Robustness to Geometrical Attacks

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Abstract—**More than ever, the growing amount of exchanged digital content calls for efficient and practical techniques to protect intellectual property rights. During the past two decades, watermarking techniques have been proposed to embed and detect information within these contents, with four key requirements at hand: robustness, security, capacity, and invisibility. So far, researchers mostly focused on the first three, but seldom addressed the invisibility from a perceptual perspective and instead mostly relied on objective quality metrics. In this paper, a novel DWT by SVD (singular value decomposition) watermarking scheme featuring perceptually optimal visibility versus robustness is proposed. The watermark, a noise like square patch of coefficients, is embedded by SVD within the wavelet domain. A perceptual model of the human visual system (HVS) based on the contrast sensitivity function (CSF) and a local contrast pooling is used to determine the optimal strength at which the mark reaches the visibility threshold. A inverse SVD method is proposed to assess the presence of the watermark. The proposed approach exhibits high robustness to various kinds of attacks, including geometrical distortions. Experimental results show that the robustness of the proposed method is globally slightly better than state-of-the-art.**

Index Terms*—*CSF, Robustness, SVD, watermarking.

I. INTRODUCTION

FACING the ever-growing quantity of digital documents transmitted over the internet, it is more than ever necessary for efficient and practical data hiding techniques to be designed in order to protect intellectual property rights. Watermarking is one such technique and has been extensively studied for the past two decades; applied to still images, it comes down to embedding an invisible information, called watermark, that can be retrieved and matched even when the watermarked image was attacked to some degree. Four key requirements have been driving researchers in designing watermarking algorithms: the invisibility, the robustness, the capacity and the security.

In this work, a robust, SVD DWT and perceptual watermarking technique is proposed. Various characteristics of the HVS are used to determine and adjust the visibility level of the embedded watermark, thus resulting in an optimal invisibility versus robustness tradeoff. The proposed technique is designed to be robust against various kinds of attacks (including geometrical distortions). .

II .BLOCK DIAGRAM

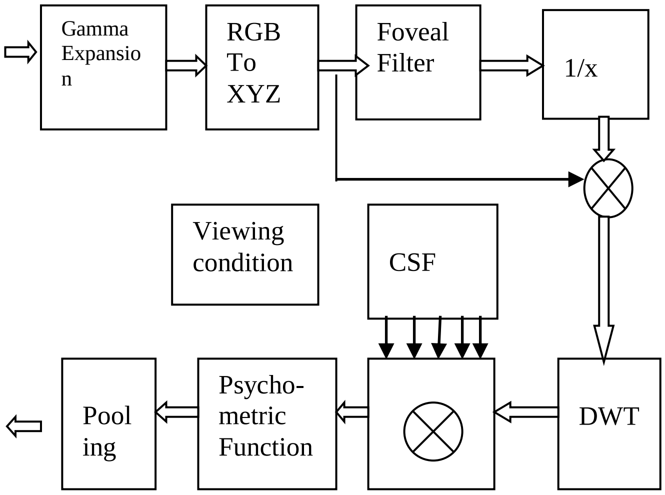

Fig 1.The proposed HVS model.

II. REACHING THE VISIBILITY THRESHOLD

In this paper, it is proposed to use some properties of the HVS to automatically determine the perceptually optimal watermarking strength, at which the embedded watermark appears at the visibility threshold. Therefore, the proposed HVS model is simplified and discards the perceptual channel decomposition. The proposed model is illustrated in Fig. 1.

A. *Modeling Viewing Conditions*

Typically, HVS models require both the viewed image and the viewing conditions to be input. Let IsRGB(x, y) denote an image to be watermarked, $0 \le x < Rx$, $0 \le y < Ry$, where Rx and Ry are respectively its horizontal and vertical resolutions.

Let Sx and Sy denote IsRGB's displayed size in meters. The display illumination is noted L; it is set to 280 cd.m−2 in the proposed model, a typical value for modern LCD monitors The viewing distance d is generally expressed as a multiplicative factor of the active image area's height, such that d = d · Sy , where d is the normalized viewing distance.

B. *From Pixel Values to Perceived Contrast*

Contrast sensitivity models generally take physical luminance in cd.m−2 as an input; digital images on the other hand are gamma encoded for display purposes. The proposed model assumes that a typical monitor (γ = 2.2) is used for display; the standard RGB (sRGB) color space will thus be used. Gamma expansion is first applied to IsRGB in order to transform the original sRGB pixel values into linear RGB values In a second step, IRGB is converted into the CIE XYZ color space. Let IXYZ denote the obtained image; its component Y is proportional to the physical luminance and will thus be used for contrast computation and watermark embedding. Michelson's formula for contrast, when applied to a sine grating of peak amplitude Apeak, defines the contrast as

$C(x, y) = Apeak/Ymean(x, y)$…………..(1)

where Ymean is the mean illumination of the area supporting the sine grating. In typical images, the illumination varies locally; Ymean thus needs to be computed locally as well. As proposed in , a raised cosine filter of diameter one degree of visual angle is applied to Y to obtain Ymean(x, y); this provides an estimate of the average foveal illumination over the entire image domain. It is proposed to normalize Y with respect to the local luminance Ymean. The locally normalized luminance map $Ylocal(x, y) = Y(x,y)/Ymean(x,y)$ may then be input toDWT computations.. Within this normalized luminance space, the local contrast of a sine grating writes as Clocal = Apeak…………. (2)

C. *Contrast Sensitivity*

Contrast Sensitivity Functions (CSFs), describing our sensitivity to contrast levels as a function of the visual frequency; the CSF returns the inverse of the threshold contrast above which a sine grating becomes visible. the CSF proposed by Mannos and Sakrison features a single.Barten provides a simplified formula for his initial CSF, which also incorporates the oblique effect and the influence of the surround luminance. In this paper, the proposed DWT SVD embedding and extraction technique is used. Barten's simplified CSF formula , at binocular viewing, will thus be used in the proposed model:

$$CSF(f,\theta) = 5200.e^{(-0.0016.f^2)} (1+100/L)^{0.008}$$

$$.(1+(144/(\theta^2 (I)))+\llbracket 0.64.f^2 (1+3\llbracket \sin\rrbracket^2 (2\theta)))^{(-0.5)}$$
$$.((63/L^{0.83} +1/(1-e^{(-0.002f^2)}))\rrbracket^{(-0.5)} \ldots\ldots\ldots.. (3)$$

where f is the visual frequency in cycles per degree (cpd), L is the adaptation luminance in cd.m−2 and is assumed to be equivalent to the display illumination ,2(I)is the square angular area of the displayed image I in square visual degrees, and θ the orientation angle.From Eqs. (2) and (3), one may now obtain the threshold amplitude Aτ peak(f, θ) of a sine grating

$A\_(peak(f,\theta)=C\_local^{\tau})^{\tau} (f,\theta)=1/(CSF(f,\theta))$………(4)
where Cτ local is the local contrast threshold.

D. *Psychometric Function*

The psychometric function is typically used to relate the parameter of a physical stimulus to the subjective responses. When applied to contrast sensitivity, may describe the relationship between the contrast level and the probability that such contrast can be perceived . In the proposed approach, Daly's Weibull parametrization is used

$\varphi\llbracket (C\rrbracket\_(local))^{(\tau*)}=1-e^{(-\llbracket c\_local^{(\tau*)}\rrbracket^{\beta})}$……..(5)

where Cτ∗local = Clocal/Cτ local is the ratio between the locally normalized contrast and its threshold value given in Eq. (4). β is the slope of the psychometric curve

E. *Watermark Frequency Pooling*

In this paper, the watermark is embedded into multiple DWT coefficients . The CSF solely provides an estimate For the visibility of a single sine grating; a summation model is thus required to estimate the combined visibility level of all embedded gratings. The proposed model will thus use probability summation as in .

IV. SVD WATERMARKING AND EXTRACTION

A. *SVD*

The singular value decomposition (SVD) is a factorization of a real or complex matrix. It has many useful applications in signal processing and statistics. The singular value decomposition of an m × n real or complex matrix M is a factorization of the form M = UΣV∗, where U is an m × m real or complex unitary matrix, Σ is an m × n rectangular diagonal matrix with non-negative real numbers on the diagonal, and V∗ (the conjugate transpose

of V, or simply the transpose of V if V is real) is an n × n real or complex unitary matrix.
In any singular value decomposition the diagonal entries are equal to the singular values of M. The columns of U and V are, respectively, left- and right-singular vectors for the corresponding singular values.

B. *Haar wavelet*

Haar wavelet is a sequence of rescaled "square-shaped" functions which together form a wavelet family or basis. The Haar sequence was proposed in 1909 by Alfréd Haar. The Haar wavelet is also the simplest possible wavelet. The technical disadvantage of the Haar wavelet is that it is not continuous, and therefore not differentiable. This property can, however, be an advantage for the analysis of signals with sudden transitions, such as monitoring of tool failure in machines. Haar used these functions to give an example of an orthonormal system for the space of square-integrable functions on the unit interval [0, 1]
$\varphi=1,0<T<1/2$
$= -1,1/2<T<1$
$=0$,otherwise.

C.*steps in watermark embedding using svd*

a)Decompose image using haar wavelet.
b)singular value decomposition of the cover image is done.
c) Choose the secret image.
d) Decompose the secret image by singular value decomposition.
e) Embedding the secret image with perceptual value 0.1.

D. *Steps in extracting watermarked secret image*

a)Wavelet decomposition of watermarked image.
b) Singular value decomposition of watermarked image.c) Extract the secret image

V .ROBUSTNESS TO ATTACKS

The robustness of the proposed watermarking algorithm to various attacks. The robustness is reported in terms of maximum of correlation against experimented attack. Different types of attacks are shearing attack, Image Scaling attack, Image Rotating attack,Image color reduction attack, JPEG compression attack, Image blurred attack, Image flip attack, cropping and intensity transformation attack, Image sharpening attack, Gaussian Noise and filtering attack,Image Contrast Attack,Speckle Noise and Filtering Attacks.The proposed method is robust to the above mentioned attacks.

VI.CONCLUSION

This paper proposes a new watermarking method. The watermark, a square patch of coefficients, is embedded by using Singular value decomposition using wavelet and watermark is extracted using inverse SVD and is robust
to various attacks.

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