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Entropy based texture watermarking using discrete wavelet transform

N. Sangeetha [a,*], X. Anita [b]

[a] Jerusalem College of Engineering, Chennai, India
[b] Department of CSE, Jerusalem College of Engineering, Chennai, India

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ABSTRACT

This paper proposes a novel image watermarking scheme using entropy of the host and texture of the watermark images. Entropy is evaluated for the discrete wavelet transform coefficients of the host image. The subband with the highest entropy is selected for embedding the texture of the watermark. Arnold transform is used to texturize the watermark and a texture is selected randomly. The level of security is increased by embedding a texture instead of watermark itself. Various experiments are conducted to analyse the proposed entropy based subband selection, linear weight evaluation, watermark embedding and watermark-host extraction. The experimental results prove that this method effectively extracts the watermark and the host images with better imperceptibility.

1. Introduction

In the era of multimedia applications among various networks; security, authentication and copyright are the major concerns towards the information transfer. To get rid of the issues either separately or collectively, various algorithms have been suggested. Among the various security algorithms available, watermarking algorithms do have the hand in all the three vulnerabilities. Watermarking schemes provide security, authorization and ownership to the multimedia information which is circulated in the open networks.

Watermarking is the process of embedding a watermark (WM) or logo into the host image without any degradation. In the later stage, watermark image can be extracted from the host for security issues such as copyright protection, tamper detection and image authentication [1,2,3]. Water marking techniques can be classified into fragile, semi-fragile and robust methods [4]. Fragile watermarking is used to establish the image authenticity by detecting unauthorized modification to the host image. Robust watermarking protects the watermark image from various attacks to ensure copyright protection and ownership verification [1]. Semi-fragile watermarking has both the fragile and robust watermarking characteristics, thus tends to detect unauthorized manipulations and also ensures authentication. Watermark embedding can be carried out either in spatial domain or in transform domain [5]. Several watermarking algorithms have been suggested based on correlation, wavelet transform and frequency domain methods [6]. Frequency domain methods are helpful for locating the region of watermark embedding that ensures better robustness of the watermarking scheme. Most of the robust watermarking schemes are carried out in frequency domain; hence the frequency coefficients of the host are modified by the

* Correspondence to: F1, Promodam Apts, 41, II Main Road, Om Sakthi Nagar, Mangadu, Chennai – 600 122, Tamil Nadu, India.
E-mail addresses: sangeethana2016@gmail.com (N. Sangeetha), anitaextee@yahoo.co.in (X. Anita).

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WM. Among the various transform domain schemes available, discrete wavelet transform (DWT) is more suitable for robust watermarking [1]. One method of finding suitable subband in DWT domain is based on entropy of subbands [7].

This paper introduces a novel semifragile watermarking scheme using the host image in wavelet domain and the texture of the WM in spatial domain. The attributes of both frequency and spatial domain are combined in this watermarking scheme. Entropy is calculated for all the subbands and the subband with the maximum entropy is selected for watermark embedding process. For watermarking, weights for the host and the WM are evaluated experimentally. The imperceptibility of extracted host and WM has very important role in the evaluation of the weights for watermark embedding process. The level of security of the watermarking can be increased by selecting one of the textures of the WM for embedding process. The texture number also has the role in watermark extraction process. Textures of the WM are derived using Arnold transform. This transform cyclically generates a texture by scrambling the WM progressively and also executes periodic property. This character of AT regenerates the original image after certain number of iterations. The periodic property of AT provides a layer of security to the watermarking scheme. Performance of this algorithm is evaluated by peak signal to noise ratio (PSNR) and mean square error (MSE). Experiments are conducted to analyse entropy based subband selection, linear weight evaluation, watermark embedding and WM-host extraction. It is also found that this algorithm is robust against noise attacks.

This manuscript is organised as follows. Section 1 gives elaborate introduction to logo watermarking and the outline of the proposed watermarking scheme. In Section 2, proposed method is explained with its illustration. Section 3 discusses experiments and results. This is followed by conclusion in Section 4.

2. Entropy based texture watermarking in DWT domain

Watermarking in frequency domain leads to better WM embedding and extraction process. Various watermarking algorithms based on DWT have been suggested by different researchers. Inoue et al. [8] decomposes a host image into subbands and selects approximate coefficients for watermark embedding process. Type of wavelet and level of decomposition are used as a 64 bit key for watermarking process and the same key should be used in WM extraction in [9]. A hybrid algorithm suggested by Anurag Mishra et al. [1] used DWT-SVD for watermarking process. In this algorithm LL subband is selected for WM embedding. Various watermarking schemes based on DWT, DWT-DCT, DCT-DWT are also available in the literature. In most of the schemes, LL subband is selected for WM embedding. This proposed method uses entropy based subband selection by calculating PSNR between watermarked image and the original host image. The following section elaborates entropy evaluation of subbands of the host image.

2.1. Entropy based subband selection in DWT domain

Transform domain processing adds another dimension of robustness to the watermarking algorithms. Type of transform, wavelets and the level of decomposition provide one layer of security to the watermarking scheme. In this algorithm, DWT is applied to the host image of size M X M using Haar wavelets. The host image is decomposed into LL, LH, HL and HH subbands with the size of M/2 X M/2. The subband for watermarking is decided based on the entropy of the subbands. Entropy is evaluated for all the subbands and the subband which has maximum entropy is selected for WM embedding. This type of subband selection leads to better watermarking performance.

2.2. Watermark embedding

The host image is decomposed into subbands using DWT and Haar wavelet. Among the subbands, HH subband is selected for watermark embedding as elaborated in Section 2.1. The WM is scrambled into textures using Arnold transform. One of textures is randomly selected and embedded into the HH subband of the host image. This texture can also be used as key for the watermark extraction, hence provide another layer of security to the watermarking process. The host image is denoted as *H(x,y)*with the size of M X M which is decomposed into LL, LH, HL and HH coefficients. The WM is denoted as *WM(x,y)* with the size *N X N,* where N = M/2. Arnold Transform (AT) is applied to the WM image which is given as

$$AT\left\{WM(x,y)\right\} = T^{n}(s,t) = \left\{T^{1}(s,t), T^{2}(s,t), \ldots, T^{L}(s,t)\right\}$$

where n is the number of iterations that changes from 1,2,3,. . .L and $T^{L}(s,t) = WM(x,y)$

The watermark embedding process is given by

$$HH_{wm} = \propto {}^{*}HH + (1-\propto)^{*}T^{n}(s,t) \tag{1}$$

Where α and (1-α) are the linear weights of the host and WM images.

Once embedding is carried out, HH_{wm} is combined with the remaining subbands of *H(x,y)*, so that inverse DWT (IDWT) can be applied to get the watermarked host image (H_{wm}) in spatial domain. This is given by

$$H_{wm} = IDWT(LL, LH, HL, HH_{wm}) \tag{2}$$

The entire watermark embedding process is given in Fig. 1