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ORIGINAL CONTRIBUTION

Digital Image Watermark Based on Discrete Wavelet Transform and Support Vector Machine

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ABSTRACT

Now days due to advancement of technology it is difficult to protect creative content and intellectual property. It is very easy to copy and modify digital media resulting in great loss in authentication. So the viable solution for this problem is digital watermarking. Digital watermarking is a technique by which we embed copyright mark into digital content which is used to identify the original creator and owner of digital media. It is prominently used for tracing copyright infringements. In this paper technique based on discrete wavelet transform is used for insertion and extraction of watermark in original image.Good learning ability of SVMs are used to extract the watermark from the watermarked image even after several different image processing attacks. This algorithm is secure and robust to various attacks, viz., JPEG Compression, Salt and Pepper noise. Design of this scheme in the Matlab Simulink is proposed.

Key words: Digital Image Watermarking; Discrete Wavelet Transform; Support Vector Machine;

1. INTRODUCTION

Digital multimedia products, such like text, images, video, audio, etc., have revolutionized in the way of extensively manipulated and transmitted in everyday of our lives. With the help of convenient ways of storing, manipulating, and accessing these data have brought lots of benefits into the digital multimedia field. However, unrestricted copying and media manipulation cause considerable financial loss and become an issue of intellectual property rights. In order to solve this problem, digital watermarking techniques have become an active research area.

2. PREVIOUS WORK

In the previous research, several watermarking schemes have been pro-posed. First the color quantization proposed by Tsai et al.,[1] introduces an approach for image watermarking by modifying the color index table. When the pixel mapping procedure for color quantization is performed, the Watermark is embedded at the same time. But, to enhance the robustness of the scheme, the distribution of colors in the palette of host image must be uniform.

Kutteret al. [2] propose a method based on amplitude modulation. In their method, robustness is improved by multiply embedding a watermark and adaptive threshold for extracting from two reference watermark bits.

The idea of amplitude modulation is further developed by combining SVM in propose an SVM-based color image watermarking algorithm.

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Recently, the image watermarking research has moved toward embed-ding the watermark in transformed coefficients because of the robustness consideration.

Mistry[3] introduced digital watermarking methods- Spatial domain (like LSB) and transform domain (like DCT, DWT) methods. The spatial domain is the normal image space, in which a change in position in image directly projects to a change in position in space. Ex.- Least Significant bit (LSB) method. Transform Domain Method produce high quality watermarked image by first transforming the original image into the frequency domain by the use of Fourier Transform, Discrete Cosine Transform (DCT) or Discrete Wavelet transforms (DWT). Authors found that transform watermarking is comparatively much better than the spatial domain encoding.

Blossom et al.[4] proposed a DCT based watermarking scheme which provides higher resistance to image processing attacks such as JPEG compression, noise, rotation, translation etc. In this approach, the watermark is embedded in the mid frequency band of the DCT blocks carrying low frequency components and the high frequency sub band components remain unused. Watermark is inserted by adjusting the DCT coefficients of the image and by using the private key. Watermark can then be extracted using the same private key without resorting to the original image. Performance analysis shows that the watermark is robust.

W. Hong et al. [5] proposed a robust digital watermarking scheme for copyright protection of digital images based on sub-sampling. The water-mark is a binary image, which is embedded in discrete transform coefficient of the host image and not used in the original image. In this scheme, they had used chaotic map in watermarked image. However the result of water-mark image is good and robust to attack.

Xia et.al [6] proposed a watermarking scheme based on the Discrete Wavelet Transform (DWT). The watermark, modeled as Gaussian noise, was added to the middle and high frequency bands of the image. The decoding process involved taking the DWT of a potentially marked image. Sections of the watermark were extracted and correlated with sections of the Original watermark. If the cross-correlation was above a threshold, then the watermark was detected. Otherwise, the image was decomposed into finer and finer bands until the entire, extracted watermark was correlated with the entire, original watermark. Performance analysis shows that DWT is more robust to attack than DCT. The problem with the proposed method is that this technique is susceptible to geometric attacks.

Akhil et al. [7] proposed a robust image watermarking technique based on 1-level DWT (Discrete Wavelet Transform). This method embeds invisible watermark into salient features of the original image using alpha blending technique. Experiment result shows that the embedding and extraction of watermark is depend only on the value of alpha. All the results obtained for the recovered images and watermark is identical to the original images.

So this proposed idea of this paper is going to give us the best result on the attacks and copyright protection with 2-level DWT.

Digital image watermarking can be done in both spatial domain and transform domain. In spatial domain the watermark bits directly added to the pixels of the cover image. Spatial domain methods can be easily modeled and analyzed mathematically. However the embedded watermark can be easily destroyed or removed by signal processing attacks such as filtering. The spatial domain technique makes use of human visual system, but sensitive to image scale so that same information must be embedded again and again in different locations of the host image. The least significant bit (LSB) method is an example of spatial domain method where the watermark is embedded into the least significant bits of the cover image. In this method, first the bit planes are extracted from the watermark and then shifted to the right. The shifted bit planes are added to the least significant bits of the cover image to get the watermarked image. The least significant bits are highly sensitive to noise, so that the watermark can easily be re-moved by image manipulations such as rotation and cropping. Thus, the LSB method provides high imperceptibility and less robustness. The correlation based method is another example of spatial domain techniques; in this method, the watermark is converted into Pseudo Noise sequence which is then weighted and added to the cover image bits. The watermarked image is compared with the cover image to detect the inserted watermark. The spatial domain methods are less complex compare to transform domain methods, however weak to different image attacks. The data hiding capacity of spatial domain techniques is higher than that of transform domain methods. Spatial domain techniques offer higher robustness to geometrical transformations.

3. DISCRETE WAVELET TRANSFORM (DWT)

The DWT is not effective to analyze non-stationary signals. Whereas short time Fourier Transform is an effective tool to do that operation, but the drawback is that it gives constant resolution at all frequencies. DWT provides both spatial and frequency description of an image with multi resolution. The multi-resolution property of the wavelet transform can be used to exploit the fact that the response of the human eye is different to high and low frequency components of the image.

DWT can be applied to an entire image without using block structure as used by the DCT, thereby reducing the blocking artifact. Wavelet is an oscillatory function of time or space that is periodic and of finite duration with zero average value. A family of wavelets can be generated by dilating and translating mother wavelet. Wavelet provides time frequency representation of a signal and is used to analyze non stationary signals.

Multi-resolution technique is used in wavelet transform where different frequencies are analyzed with different resolutions. Big wavelets give an approximate value of a signal, while the smaller wavelets boost up the smaller details. DWT is computed either by using convolution based or lifting based procedures. In both the methods, the output sequence decomposed into low-pass and high-pass sub bands, where each sub bands constituting of half the number of samples of the original sequence. The DWT represents an NxN image by N2 coefficients. The DWT can be implemented through filter bank or lifting scheme.

The DWT of an image is analyzed by allowing it to pass through an analysis filter bank followed by down sampling. The analysis filter bank consists of low-pass and high-pass filters at decomposition stage. When an image passes through these filter banks, the image split into two sub bands. The low-pass filter performs averaging operation and extracts the coarse information of the image. Whereas the high-pass filter performs difference operation and extracts the details of the image. Then the output of the filtering operation is down sampled by two. This operation splits the image into four bands, namely, LL, LH, HL, and HH.

The lowest resolution level LL consists of the approximation part of the original image and most of the energy is concentrated in this LL band. Hence modifications of this low frequency sub band would cost severe and unacceptable image degradation. So the watermark is not embedded in LL sub band. The good areas for watermark embedding are high and middle frequency coefficients (vertical, horizontal and diagonal coefficients). Human visual system is insensitive to these high and middle frequency sub bands and effective watermark embedding is achieved without being perceived by human visual system.

3.1 SIGNALS AND WAVELETS

Wavelets are functions generated from one single function (t) by dilations and translations

$$\mathbf{\Psi_{a,b}\,(t)=1/\sqrt{a}\ \Psi(\ t\text{-}\ b/a)}$$

(For this introduction we assume t is a one-dimensional variable). Wavelets are functions defined over a finite interval and having an average value of zero.

The mother wavelet has to satisfy dx + (x) = 0, which implies at least some oscillations. If (t) decays faster than It1 for t + 03, then this condition is equivalent to the one above. The definition of wavelets as dilates of one function means that high frequency wavelets correspond to a < 1 or narrow width, while low frequency wavelets have a > 1 or wider width. The basic idea of the wavelet transform is to represent any arbitrary function f as a superposition of wavelets. Any such superposition decomposes f into different scale levels, where each level is then further decomposed with a resolution adapted to the level. One way to achieve such a decomposition writes f as an integral over a and b of q,h with appropriate weighting coefficients. In practice, one prefers to write as a discrete superposition (sum rather than integral).

3.2 WAVELET

$$\boldsymbol{\Psi_{s,}\ \tau\,(t) = 1/\sqrt{s}\ \Psi((t-\tau)/s)}$$

where τ =shift in time

S= change in scale: big S means long wavelength

$1/\sqrt{s}$=normalization

$\Psi_{s,}\ \tau\,(t)$ = wavelet with scale S and time = τ

3.3 WAVELET TRANSFORM

Where f(t)= time series

$\Psi^*_{s,\tau(t)}$ = complex conjugate of the wavelet with scale S and time

the complex conjugate is not considered from now on assuming Real Wavelets are being used

$\gamma(s,\tau)$=coefficients of wavelet with scale S and time

$$\boldsymbol{\gamma(s,\tau)=\int f(t)\Psi^*_{s,\tau(t)}\ dt}$$

3.4 INVERSE WAVELET TRANSFORM

$f(t) = \iint \gamma(S,\tau)\ \Psi_{s,\tau}(t)\ d\tau\ ds$

where f (t) = time series

$\gamma(S,\tau)$ = coefficients of wavelets

$\Psi_{s,\tau}(t)$ = wavelet with scale S and time

Therefore, inverse wavelet transform builds up a time-series as sum of wavelets of different scales, s, and positions, t

4. ALGORITHM

4.1 EMBEDDING

input: 2 images- host image, watermark

1. cputime is noted as start time

2. select the degree of embedding k

3. perform Single-level discrete 2-D wavelet transform and get the corre-sponding coefficients of host image

4. for each pixel of the watermark

4.a. if pixel value is zero embed the watermark into the host image horizontally embed the watermark into the host image vertically

5. perform Inverse single-level discrete 2-D wavelet transform

6. write the watermarked image into a file

7. total elapsed time is computed as start time subtracted from cpu time

4.2 EXTRACTION

input: watermarked image

1. cputime is noted as start time

2. on the watermarked image perform Single-level discrete 2-D wavelet transform and get the coefficients

3. for each pixel of the original watermark

3.1. correlate the coefficients of the watermarked image Horizontally

3.2. correlate the coefficients of the watermarked image vertically

3.3. mean correlation is computed as the average of the horizontal and vertical correlation

4. for each pixel of original watermark

5. If Correlation is greater than the Mean Correlation, then put pixel = 0 6. write the recovered watermark into a file.

7. Total elapsed time is computed as start time subtracted from cpu time

5. AN INTRODUCTION TO SUPPORT VECTOR MACHINES

Introduction

The support vector machines (SVMs) is a machine learning tool or a universal classification algorithm used for performing classification and detection tasks.

SVM has emerged in recent years as a popular approach to the classification of data. SVM is margin-based classifier with good generalization capabilities. It is the method of creating functions from a set of labelled training data. SVM finds an optimal separating hyper-plane between data points of different classes in a high dimensional space. Support vectors are the points that form the decision boundary between classes.

In SVM algorithm two sets of vectors are considered, one is of real numbers and the other is output vector consisting of positive and negative examples.

SVM Classification Model

SVM performs pattern classification between two classes to find a decision surface that has maximum distance to the closest points in the training set. For a linearly separable data, such a hyper-plane is determined by maximizing the distance between the support vectors. For a linearly separable data, such a hyper-plane is determined by maximizing the distance between the support vectors. Consider n training pairs (x_i,y_i), where x_i 2 R^N and y $_i$ 2 [1.-1], the decision surface is defined as:

f(x) =

$$\sum_{i-1}^{n} \alpha_i y_i x_i^T . x+b \ldots\ldots\ldots\ldots(1)$$

where the coefficient $_i$ > 0 is the Langrange multiplier in an optimization problem.

A vector x_i that corresponds to $_i$ > 0 is called a support vector. f(x) is independent of the dimensions of the feature space and the sign of f(x) gives the membership class of x.

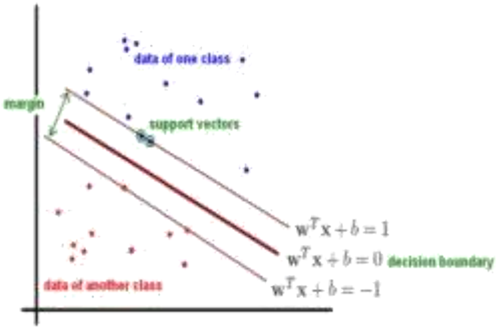

Figure 1: SVM Classifier

Simplest case: linearly-separable data, binary classification

Goal: we want to find the hyperplane (i.e. decision boundary) linearly separating our classes. Hyper plane is the separating plane between positive and negative examples.

Our boundary will have equation: $w^T.x+b = 0$

Anything above the decision boundary should have label 1. i.e., x_i s.t. $w^T:x_i + b > 0$ will have corresponding $y_i = 1$.

Similarly, anything below the decision boundary should have label -1. i.e., x_i s.t. $w^T:x_i + b < 0$ will have corresponding $y_i = -1$.

The reason for this labelling scheme is that it lets us condense the formula-tion for the decision function to $f(x) = sign(w^T:x + b)$ since f(x) = +1 for all x above the boundary, and f(x) = -1 for all x below the boundary.

Thus, we can figure out if an instance has been classified properly by checking that $y(w^T:x+b) >= 1$ (which will be the case as long as either both $y,w^T:x+ b > 0$ or else $y,w^T:x + b < 0$).

6. RESULT

Using the algorithm, the corresponding code was executed and successfully the outputs were obtained.

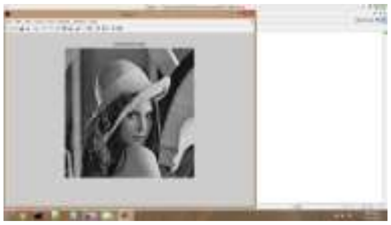

Figure 2: Original Host Image

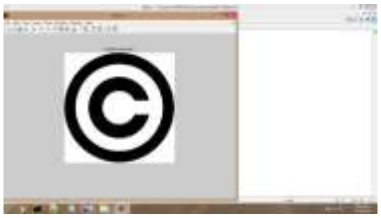

Figure 3: Original Watermark

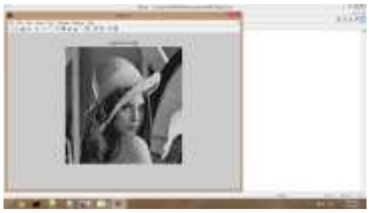

Figure 4: Watermarked Image

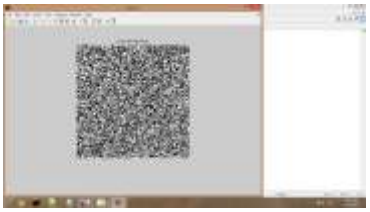

Figure 5: Recovered Watermark

7. CONCLUSION

In this paper, a novel Image watermarking scheme using discrete wavelet transform based on the support vector machines have been presented. The experimental results in this paper have demonstrated that SVM based de-coding is quite effective in a hostile environment. We have used this technique for image watermarking, but this methodology can also be applied for audio and video watermarking.

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