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New Watermarking Scheme for Gray Image Based on DWT and SVD-DCT

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Abstract

This paper presents a new reference watermarking scheme based on Discrete Wavelet Transform (DWT) synchronised with singular value decomposition and Discrete Cosine Transform (SVD-DCT).DWT is a wavelet transform for which the wavelets are sampled discretely. SVD is a new and important transfer technique in robust digital watermarking due to its different properties from traditional transform techniques such as DCT and DWT. This paper analyse the watermarking techniques of gray image on the basis of its peak signal to noise ratio (PSNR) value. The simulation results show that in the proposed algorithm, the image is being preserved with the increase in PSNR value under several attacks.

Keywords: Watermarking, embedding, Discrete Wavelet Transform (DWT), Singular value decomposition (SVD), Discrete Cosine Transform (DCT), Peak signal to noise ratio (PSNR), Simulation

Introduction

Digital image watermarking is the process of embedding information into a digital signal which may be used to know about its authenticity or the identity of its owners and producers, in the same manner as document having a benchmark for visible identification. In digital watermarking, the signal may be audio, image, or video. If the signal is copied, then the information also is contained in the copy. A signal may contain different watermarks at the same time[6],[7].

Discrete Wavelet Transform (DWT)

In functional analysis and numerical analysis, a discrete wavelet transform (DWT) is a wavelet transform for which the wavelets are sampled discretely. A advantage it has over Fourier transform is temperary resolution: it captures both frequency and time. It can distill the information from signal properly[2].

The basic idea of discrete wavelet transform in image processing is to multi-differentiate and decompose the image into sub-image of different spatial domain and independent frequency district [8][1] and then transform the coefficient of sub-image. After the cover image has been DWT transformed, it is decomposed into four frequency parts.The lowest frequency information is in the s3-s3 sub-band and the highest frequency information is in the d1-d1 sub-band (Figure-1).

The three high-frequency parts (s-d,d-d,d-s)is as shown in figure. If the information of low-frequency part is DWT transformed, the sub-level frequency part information will be obtained. Here s represents low-pass filter and d represents high-pass filter. An original image can be decomposed into frequency parts of s1-d1,d1-d1 and d1-s1 . The low-frequency district information can also be decomposed into sub-level frequency part information of s2-s2,d2-s2 ,d2-d2 and s2-d2.

The data of low frequency part is an image close to the cover image. Most signal information of cover image is in this frequency part. The frequency part of d-s, frequency part. The frequency part of d-s, s-d and d-d represents the level detail, the upright detail and the diagonal detail of the cover image.

According to the character of HVS, human eyes are sensitive to the change of smooth part of image, but not sensitive to the small change of edge profile.

Therefore, it's hard to conscious that putting the watermarking signal into the big amplitude coefficient of high-frequency band of the image DWT transformed. Then it can carry more watermarking signal and has good concealing effect.

The decomposing process of DWT for image frequency is alike the signal disposing process of HVS .By using the characters of de lamination DWT, the concealing and the robustness of watermark can be balanced. Then it become the main choice of watermark embedding in transformed domain.

Figure 1: Map of image DWT decomposed

Singular Value Decomposition (SVD)

According to linear algebra, the singular value decomposition (SVD) is a factorization of a real or complex matrix, with many helpful advantages in signal processing and statistics. Normally, the singular value decomposition of an $m \times n$ real or complex matrix *M* is a factorization of the form

$$M = U \sum V^*$$

$$M = U\Sigma V*$$

where *U* is an $a \times a$ complex or real unitary matrix, Σ is an $a \times b$ diagonal matrix with nonnegative real numbers on the diagonal, and $V*$ is an $b \times b$ real or complex unitary matrix. The diagonal entries $\Sigma_{i,i}$ of Σ are known as the singular values of *M*. The a columns of *U* and the b columns of *V* are called the left singular vectors and right singular vectors of *M*, respectively. Singular value decomposition and Eigen decomposition are related. Namely:

- The left singular vectors of *M* are eigenvectors of MM^* .
- The right singular vectors of *M* are eigenvectors of $M^* M$.
- The non-zero singular values of Σ are the root square of the non-zero Eigen(small) values of $M^* M$ or MM^* [5].

The Singular Value Decomposition of a rectangular matrix *A* is a decomposition of the form

$$\boldsymbol{A = USV^T}$$

where *S* is a diagonal matrix and *U* and *V* are orthogonal matrices,. The columns of v_i and u_i of *V* and *U* matrix are called the right and left singular vectors, and the diagonal elements s_i of *S* are known as the singular values. The singular vectors form orthonormal bases, and the major relation

$$A\, v_i = s_i\, u_i$$

represents that every right singular vectors are mapped onto the corresponding left singular vector, and the "magnification factor" is the concerned to singular value.

Diagram (Figure 2) represents left singular vectors u_i for i=1,...,20 of a matrix arising from the discretization of a Freehold integral equation of the first kind arising in light scattering. The number of oscillations in u_i increases with *i*. The SVD has number of advantages in scientific computing, signal processing, automatic control, and many other fields.

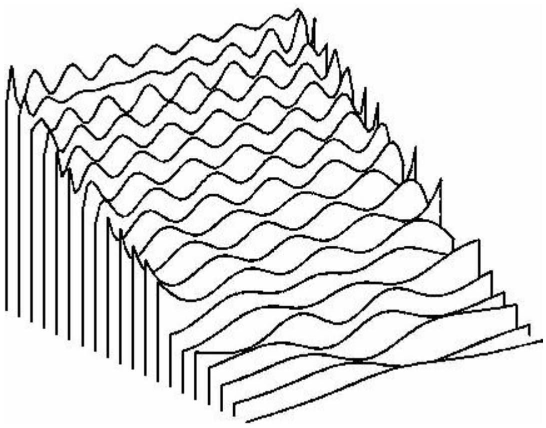

Figure 2: Singular Vectors

DCT (Discrete Cosine Transform)

DCT is a Fourier-related transform same as the Discrete Fourier transform, but using real numbers.DCT turn over the image edge to make the image transformed into the form of even function. It is one of the most common linear transformations in digital signal process technology.

The most common variant is the type-II DCT, which is called simply "The DCT"; and its inverse, the type-III DCT, is correspondingly called simply "the Inverse DCT" or "the IDCT". The 2-D DCT is defined as[2]:

$$F(jk) = a(j)a(k)\sum_{m=0}^{N-1}\sum_{n=0}^{N-1} f(mn)\cos\left[\frac{(2m+1)j\Pi}{2N}\right]\cos\left[\frac{(2n+1)k\Pi}{2N}\right]$$

The corresponding inverse transform (2D-IDCT) is defined as:

$$f(mn) = \sum_{m=0}^{N-1}\sum_{n=0}^{N-1} a(j)a(k)F(jk)\cos\left[\frac{(2m+1)j\Pi}{2N}\right]\cos\left[\frac{(2n+1)k\Pi}{2N}\right]$$

Two relative transforms are the discrete sine transforms (DST), which is equal to a DFT of real and odd functions, and the modified discrete cosine transforms (MDCT), is based on a DCT of overlapping data.

Peak Signal-to-Noise Ratio

The phrase peak signal-to-noise ratio, which is PSNR, is an engineering term for the ratio between the maximum possible power of a signal and the power of distorting noise that affects the fidelity of its representation. Because many signals have a very wide dynamic range, PSNR is usually expressed in terms of the logarithmic decibel scale[9].

The PSNR is commonly used for the measurement of quality of reconstruction of compression coders. The signal in this case is actual data, and the noise is the error or distortion introduced by compression. When comparing compression codec's is used as an approximation to human perception of reconstruction quality, therefore in few cases one reconstruction may appear to be near to the original than other, even though it has a lower PSNR ,a higher PSNR would normally indicate that the reconstruction is of higher quality. One has to be extremely careful with the range of validity of this metric; it is only conclusively valid when it is used to compare results from the same codec or codec type and same data.It is most easily defined via the mean squared error (MSE) which for two $m \times n$ monochrome images I and K where one of the images is considered a noisy approximation of the other is defined as:

$$MSE = \frac{1}{mn} \sum_{i=0}^{m-1} \sum_{j=0}^{n-1} [I(i,j) - K(i,j)]$$

The PSNR is defined as

$$\text{PSNR} = 10.\ \text{Log}10\left(\frac{MAX}{MSE}\right)$$
$$= 20.\ Log10\left(\frac{MAX}{\sqrt{MSE}}\right)$$

Here, MAX_I is the maximum possible pixel values of the cover image. When the pixels are represented using 8 bits per sample, this is 255. Generally, when samples are represented using linear PCM with B bits per sample, MAX_I is $2^B - 1$. For color images with three RGB values per pixel, the definition of PSNR is the same except the MSE is the sum by comparing all squared value differences divided by image size and by three. Alternately, for color images the image is converted to a different color space and PSNR is reported against every channel of that color space.

Typical values for the PSNR in lossy image and video compression are between 30 and 50 dB, where higher is better. transmission quality loss are considered to be about 20 dB to 25 dB[9].When the two images are identical, the MSE will be zero. For this value the PSNR is undefined.

Watermark Embedding and Extracting Procedure

The combined features of DWT and SVD- DCT are exploited in this watermarking algorithm. The watermark embedding algorithm proposed here firstly divides the original picture or the host picture into wavelets and then hide several bits of the watermark in every SVD–DCT block in the positions selected on a pseudo-random basis as we permute it randomly. Following are the steps for the proposed work:

Step 1: We take a original image,which has to be watermarked, transformed it by using Discrete Wavelet Transform(DWT) algorithm.

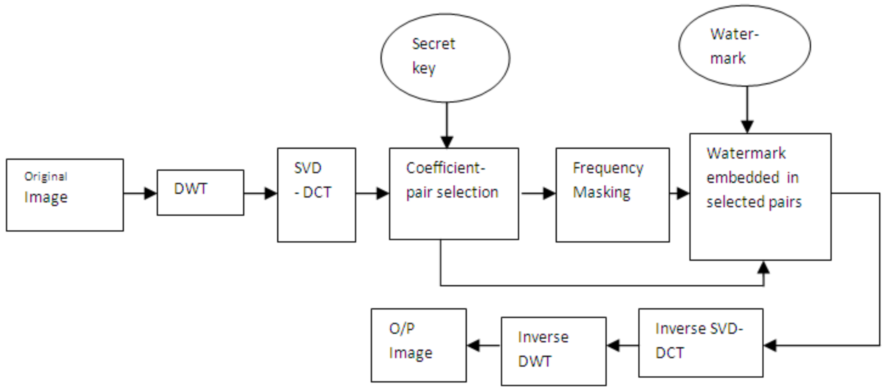

Figure 3: Block Diagram of proposed Scheme

Step 2: In this step,we performed the Singular Value Decomposition (SVD) to convert it into a matrix form.Then the resulting matrix is converted into sub- blocks using Discrete Cosine Transform(DCT).These sub blocks are called SVD-DCT coefficient blocks.

Step 3: We select the coefficient pair which are to be modified in the potential positions of the SVD and DCT block.Compute the frequency mask to determine the level of tolerance against distortions caused by the watermark embedding. A linear model for frequency mask is generated as follow $Mask = \alpha * edge + \beta$

Where α is a parameter for controlling the local embedding strength of the watermark,and β is the base strength of the watermark which is needed to resist the effect of the rounding and truncation operations.

Step 4: In this step,high frequency selected pairs and the low frequency pairs, which are frequency masked, are combined to constitute the complete picture. Then watermark is embedded on the combined picture.

Step 5: In this step , the positions of the watermarked coefficient pairs are recovered in each SVD-DCT block according to the secret key.Then the inverse transform of DWT is applied to obtain the watermarked image.This is done by uniting the information of the mended high frequency and low frequency band.

Area of Field

Digital watermarking may be used for a wide range of applications, such as

- Copyright protection
- Source tracking (different recipients get differently watermarked content)
- Broadcast monitoring (television news often contains watermarked video from international agencies)
- Covert communication

Results and Discussions

In order to explore the performance of the previous watermarking algorithm. MATLAB platform is used on different images of different-different sizes which are LENA, PEPPER and MANDRILL logo used is: IT. In previous technique, a semi-blind reference watermarking scheme is presented in which the watermark is a visually meaningful gray scale logo. The embedding is done by modifying the singular values of reference image with the singular values of the watermark and then the signal is reconstituted. The observations regarding the proposed watermarking scheme can be summarized as follows: After taking wavelet decomposition, we form reference image, which shows the high frequency information of an image and the relative intensity of high frequency to the background. It gives the adjustability to the user, for making reference image in the form wavelet coefficients. The security of the proposed method lies in the reference image, If any intruder tries to remove the watermark then the watermark is removed by degrading the image quality. Hence, the quality of the image degradation is directly proportional to the quality of the extracted logo.

Leena | Pepper | Mandrill

Figure 4: Host images for watermarking

Figure 5: Watermark

Results from Previous Scheme (DWT-SVD) watermark used is IT

Table 4.1: PSNR values for image LEENA

IMAGES	PSNR VALUES
LENA	43.65
PEPPER	44.12
MANDRILL	40.93

Results from Proposed Scheme (DWT,SVD-DCT) watermark used is IT

Table 4.2: PSNR values of all test images

IMAGES	PSNR VALUES
LENA	46.76
PEPPER	46.77
MANDRILL	46.76

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