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A STUDY OF DIGITAL IMAGE WATERMARKING TECHNIQUES

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ABSTRACT

Digital media and internet technologies are growing rapidly with some of the major issues being copyright protection, copy protection and integrity verification. Digital Image watermarking provides copyright protection of digital images by hiding appropriate information on the digital image. In general digital image watermarking can be performed in spatial domain and transform domain where the properties of underlying domain can be exploited. Discrete Wavelet Transform (DWT), Singular Value Decomposition(SVD), ARNOLD, Discrete Cosine Transform(DCT), Discrete Fourier Transform(DFT) are the traditional watermarking algorithms which solve only one purpose, however some multipurpose digital watermarking methods have been proposed through which content authentication can be achieved. In this research work, a comparative study of different watermarking techniques have been proposed.

Keywords: Multimedia, Copyright Protection, Image Watermarking, Discrete Wavelet Transform, Singular Value Decomposition, Discrete Cosine Transform, Discrete Fourier Transform

I INTRODUCTION

Watermarking (data hiding) [1, 2, 3] is the process of embedding data into a multimedia element such as image, audio or video. This embedded data can later be extracted from, or detected in, the multimedia for security purposes. Digital watermarking has attracted considerable attention and has numerous applications, including copyright protection, authentication, secret communication, and measurement [4], [5].

Whether watermarking algorithm is valid or not, is mainly based on two following characteristics: First, the invisibility, which means that watermarking should be invisible and do not affect original digit to be protected; Second, the Robustness, which means that extracted watermarks are still significant after suffering from all kinds of signal processing such as filtering, compressing, rotating, scaling, cropping operations, etc. [6]

Now, all watermarking algorithms, according to its embedded way on the whole, can be classed into two types: the space domain and the transformation domain. They have different characteristics, from the point of view of the ability to resist attacks. Transformation domain algorithms are widely thought better than those of the space domain.

The transformation domain algorithms are generally orthogonal transformation, such as the Fourier transform, the DWT and the SVD.

II ARNOLD TRANSFORM

A digital image can be considered as a two unit function f(x,y) in the plane Z. It can be represented as Z = f(x, y) where x, y ∈ {0,1,2,3....N −1} and N represents order of digital image. The image matrix can be changed into a new matrix by the Arnold transform which results in a scrambled version to offer security. It is a mapping function which changes a point (x, y) to another point (x1, y1) by the equation (1).

$$\begin{aligned} x' &= (x+y) \bmod N \\ y' &= (x+2y) \bmod N \end{aligned} \qquad (1)$$

2.1 Arnold Scrambling

The K×K binary watermark image W is transformed into W' by Arnold transformation to lower the autocorrelation coefficient of image and then the confidentiality of watermark is strengthened. Arnold transformation is periodic and when it is iterated sometimes the original signal is retrieved. The Arnold transformation is given by

$$\begin{bmatrix} x' \\ y' \end{bmatrix} = \begin{bmatrix} 1 & 1 \\ 1 & 2 \end{bmatrix} \begin{bmatrix} x \\ y \end{bmatrix} (\text{mod } K)$$

2.2 Singular Value Decomposition

Singular value decomposition (SVD for short) in numerical analysis is the numerical method of diagonalizable matrix. The reason of applying SVD in image processing is that singular value embodies the intrinsic characteristics of image and the stability is very good, namely there is no obvious change in the singular value when the image is disturbed by a small perturbation. We apply this algorithm to digital watermark, which is beneficial to maintain the robustness of watermark. In china the earliest image digital watermarking algorithm based on singular value decomposition is the algorithm proposed by Liu Ruizhen and Tan Tieniu in 2001. This embedded algorithm cannot detach from the original image in this watermarking checking algorithm. So this algorithm is more cumbersome and time-consuming is larger. Afterwards, Hu Zhigang and Zhang Zhiming etc. [8-11] separately proposed different watermarking algorithms based on singular value decomposition. In these studies, some combined with DCT domain, some combined with DWT domain, and some combined with the character of human visual system (HVS).

For the watermarking embedded position, some embedded in the first maximum, some embedded in the other smaller singular value except the maximum. The emphasis points of these algorithms are different, some emphasized the robustness of watermark, and some emphasized the invisible and imperceptibility of watermark.

Let **A** be a general real (complex) matrix of order$m \times n$. The singular value decomposition (SVD) of A isthe Factorization

$$A = U * S * V^T \qquad (1)$$

Where **U** and **V** are *orthogonal (unitary)* and $S = diag(\sigma 1,\ \sigma 2,\ \ldots,\ \sigma r)$,where $\sigma i,\ i = 1,2,\ldots\ r$ are the singular values of the matrix A with $r = min(m, n)$ and satisfying

$$\sigma 1 \geq \sigma 2 \geq \ldots \geq \sigma r \qquad (2)$$

The first r columns of V the right *singular vectors* and the first r columns of U the *left singular vectors*.

Use of SVD in digital image processing has some advantages. First, the size of the matrices from SVD transformation is not fixed. It can be a square or a rectangle. Secondly, singular values in a digital image are less affected if general image processing is performed. Finally, singular values contain intrinsic algebraic image properties.

The SVD mathematical technique provides an elegant way for extracting algebraic features from an Image. The main properties of the SVD matrix of an image can be exploited in image watermarking. The SVD matrix of an image has good stability. When a small perturbation is added to an image, large variation of its SVs does not occur [3, 4]. Using this property of the SVD matrix of an image, the watermark can be embedded to this matrix without large variation in the obtained image.

III DISCRETE WAVELET TRANSFORM

The algorithm in [12] divides carrier image into sub blocks in wavelet transform domain and watermark is embedded in each block. But in the process the watermark embedding strength is changeless and it doesn’t obtain optimal embedding. SVM (support vector machine) is used in [13] to learn the inherent relationship between root node and its descendant’s nodes after the original image is decomposed by wavelet transform. And then the output value in the model is adjusted bigger or smaller than the target value to embed watermark. In the algorithm the embedding strength is changed in different locations, but it spends a long time because SVM is used in the process of watermark embedding and watermark extraction.

Wavelet transform is a multi-scale signal analysis method, which overcomes the weakness of fixed resolution in Fourier transform. In the wavelet transform domain the general features and the details of a signal can be analyzed. After wavelet transform the two-dimensional image is decomposed into four sub-images and each of them is a quarter size of the original image. One of the sub-images is a low-frequency sub-band which can be decomposed continually and the others are high-frequency sub-bands in the horizontal direction, vertical direction and diagonal directionrespectively. The image after wavelet transform forms a tree structure arranging from low to high frequency bands. Every wavelet coefficient in the low-frequency sub band is a root of the tree, which has three

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children locating at three inferior low-frequency sub-bands respectively. The other sub-bands all have four children locating at the highersub-bands.

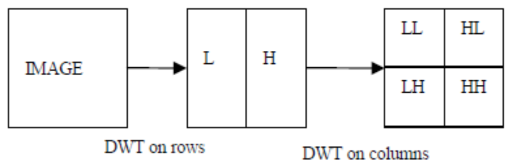

Figure 1. DWT decomposition

DWT can well-match the HVS (Human Visual System) features, and also be compatible with the JPEG2000, MPEG4 compression standard. The watermark generated by DWT has well visual effects and resistance to a variety of attacks. These features have laid a solid foundation for designing digital watermarking algorithms.

IV DISCRETE FOURIER TRANSFORM

As DFT has invariance to translation, rotation, scaling, the DFT-based Digital Watermarking Algorithm has unique advantages in the resistance geometric transformations, the algorithms proposed in the literatures [14, 15] are based on the DFT watermark scheme.

At present, the research of Image watermarking techniques require a relatively higher robust of watermark, an algorithm with pseudo-random noise to construct the watermark and use test to find the watermark in detected. When the image be detected extracted test sequence has a strong relevance with the original watermark.

Basically the Fourier transform is a most popular technique for signal analysis, signal study and synthesis to define the effect of various factors on signal. Sometime the Fourier transform is use to transform the signal from time domain to frequency domain or signal from frequency domain to time domain. This transformation is reversible and that maintaining the same energy. The following formula gives the Fourier transform and its inverse transform.

$$\mathrm{F}\,(\boldsymbol{\omega}) = \int_{-\infty}^{\infty} f(t)\, e^{-j\boldsymbol{\omega} t}\, dt \qquad (1)$$

$$\mathrm{F}\,(t) = (1/2\pi) \int_{-\infty}^{\infty} F(\omega)\, e^{j\boldsymbol{\omega} t}\, d\boldsymbol{\omega} \qquad (2)$$

The analysis of Fourier transform theory also define the both continuous time signals and discrete time signals but the computer only define the discrete signals so that first of all the Discrete Fourier Transform (DFT) forms. Let us consider n is a discrete time-domain variables, and k is a discrete frequency domain variables, then the Fourier transform can be defined-

$$\mathrm{F}\,(k) = \sum_{n=0}^{N-1} f(n)\, e^{-j2\pi kn/N}, \qquad k=0, 1, 2, \ldots\ldots N-1 \qquad (3)$$

$$f(n) = (1/N) \sum_{k=0}^{N-1} F(k)\, e^{j2\pi kn/N}, \qquad n=0, 1, 2, \ldots\ldots N-1 \qquad (4)$$

here the f (n) is a real function and F(k) is a complex function. The watermark can be embedded in amplitude function F (k).

V DISCRETE COSINE TRANSFORM

DCT like a Fourier Transform, represents data in terms of frequency space rather than an amplitude space. This is useful because that corresponds more to the way humans perceive light, so that the part that are not perceived can be identified and thrown away. DCT based watermarking techniques are robust compared to spatial domain techniques. Such algorithms are robust against simple image processing operations like low pass filtering, brightness and contrast adjustment, blurring etc. However, they are difficult to implement and are computationally more expensive. At the same time they are weak against geometric attacks like rotation, scaling, cropping etc. DCT domain watermarking can be classified into Global DCT watermarking and Block based DCT watermarking. Embedding in the perceptually significant portion of the image has its own advantages because most compression schemes remove the perceptually insignificant portion of the image [16][17].

5.1 Basics of DCT

DCT separates images into parts of different frequencies where less important frequencies are discarded through quantization and important frequencies are used to retrieve the image during decompression. Compared to other input dependent transforms

DCT has many advantages: (1) It has been implemented in single integrated circuit; (2) It has the ability to pack most information in fewest coefficients; (3) It minimizes the block like appearance called blocking artifact that results when boundaries between sub images become visible [18].

VI CONCLUSION

Digital watermarking is very useful method for providing security to the digital media on the internet technology. In this paper, survey of different techniques based on spatial domain (LSB) and the transform domain (DCT, DWT, DFT).

A number of contemporary digital watermarking techniques exist to support copy right protection for Internet users. This paper has discussed the importance of these watermarking methods for understanding them and a help for new researchers in related areas.

Digital watermarking is still a challenging research field with many interesting problems, like it does not prevent copying or distribution and also cannot survive in every possible attack. One future research pointer is the development of truly robust, transparent and secure watermarking technique for different digital media including images, video and audio.

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