A STUDY OF DCT-SVD BASED ROBUST WATERMARKING SCHEME

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ABSTRACT

In this paper, the authors have presented the study of digital watermarking scheme which employs both the Discrete Cosine Transform (DCT) and the Singular Value Decomposition (SVD). The study discuss that how an original greyscale image can be secured by robust digital watermarking. In this paper it has been discussed how block based DCT and SVD transformation together can form a hybrid watermark which has a very good quality of withstanding quality against various noise. Block based DCT transform the whole image into several blocks based on their frequency range and gives a frequency spectrum. At the middle band of spectrum watermark is embedded which gives less chance of distortion on cover image as well as more withstanding capability against compression attack. SVD transformation on reduced image make it more robust and less visible. Various results of this technique shows it’s success as a hybrid approach than a normal one.

General Terms
Multimedia Security

Keywords: Digital Watermarking, Discrete Cosine Transform (DCT), Robust Watermarking Scheme, Singular Value Decomposition (SVD).

INTRODUCTION

Invention of computer and ‘information explosion’ by internet makes a revolutionary growth in the area of digital data and information that includes all types of text and multimedia data. It also makes the exchange of data and information extremely simple and fast. But as a bad affect the illegal manipulation, counterfeiting and tampering of data become pose a threat. To prevent this kind of malpractice and protecting rightful ownership digital watermark comes up as a solution. Digital watermark serve the purpose of security related issues very successfully. It also protects the intellectual property rights.

In digital watermarking technique, the watermark is employed into the actual image which is called host image or cover image. If after the attack on actual image the watermark remained intact or minimally distorted then only we can say that the watermark has served its purpose. When the watermark will be embedded into the cover image it is desired that the actual cover image should be minimally changed. Even human eye can’t distinguish between watermark and the actual cover image.

The basic attributes for a good watermarking technique are as follows:

Transparency: HVS should not be able to detect the presence of watermark in naked eye. That it should be invisible to the others and only the actual cover image will be visible.

Robustness: Robustness is one of the most vital aspects to develop a good watermark. It refers to the withstanding capability against accidental or deliberate attacks. Like compression, rotation, scaling, different types of noises, cropping etc. Based on robustness watermarking can be of different types. These are generally fragile, semi fragile and robust. The main goal of watermark is, the attacker should not be able to change the watermark without changing the host image. Though in case of fragile watermark any change in host data will affect the watermark. It is used to prove the authenticity.

Security: As watermark is a part of encryption, so it always provides a key to embed it into the cover image and also extract it from the watermarked image.

Payload: The capacity of holding watermark bits into the cover image. It determines the size of the watermark that can reside into the image.

Embedding the watermark is not only the answer to the concern related to security and authenticity. But the quality is also a need.

Generally watermark can be done on both spatial domain and transform domain[1]. In spatial domain the watermark is inserted directly into the image by replacing some bits from that particular cover image [1]. The advantage in spatial domain is that it is easy to implement and less complex. But the watermark is not very robust. So the transform domain was introduced. It requires more numerical and analytical calculation [2-5]. In this domain watermarking is not directly embed into the image but first the cover image transform into frequency and the watermark is inserted. The transform is generally done by using DCT, DFT, SVD, DWT techniques [2-4].
Now a days to overcome the challenges related to security and authenticity hybrid watermarking technique trends have emerged [4]. In this scheme instead of using one transform domain technique, more than one transform domain have been used i.e. combination of more than one transform domain technique is used to embed a watermark. The utility of hybrid technique is that more than one transform domain technique is used and they work like substitute of each other. By this way we can overcome the drawback of one by using the other. In this paper authors have discussed how this scheme is.

PRELIMINARIES

As mentioned earlier that watermark can be embedded into the cover image either in spatial or transform domain and using transform domain instead of spatial domain is always a better approach because of robustness is higher in earlier one. This can be done by using different transforming tools like DCT, SVD, DWT etc. Both the DCT and the SVD have wide applications for implementing a robust watermarking schemes either individually or together. In this section, we will briefly review the used transformations tools like block based DCT and the SVD in the context of devising a robust digital watermarking scheme.

Block based DCT

The DCT [16] is one of the popular and widely used signal decomposition as well as compression techniques that transform a signal from spatial representation into a spectral representation with an inherent ability to exhibit excellent energy compaction for the concerned signal or image. It basically transforms the signal or image as a sum of sinusoids of varying magnitudes and frequencies. In block based DCT, the input image, \( f \) of size \( M \times N \) pixels is decomposed into non-overlapping blocks of size \( m \times n \) and then each block \( f_b \) is transformed into corresponding DCT coefficients according to the following equation

\[
F_b(u,v) = \alpha(u) \alpha(v) \sum_{x=0}^{m-1} \sum_{y=0}^{n-1} f_b(x,y) \cos \left( \frac{(2x+1)\pi u}{2m} \right) \cos \left( \frac{(2y+1)\pi v}{2n} \right)
\]

(1)

where

\[
\alpha(u) = \begin{cases} 
\frac{1}{m} & \text{for } u = 0 \\
\frac{1}{\sqrt{m}} & \text{for } u = 1, 2, \ldots, m-1
\end{cases}
\]

\[
\alpha(v) = \begin{cases} 
\frac{1}{n} & \text{for } v = 0 \\
\frac{1}{\sqrt{n}} & \text{for } v = 1, 2, \ldots, n-1
\end{cases}
\]

(2)

for \( u = 0, 1, 2, \ldots, m-1 \) and \( v = 0, 1, 2, \ldots, n-1 \)

The sub-image is reconstructed from the transformed sub-image block \( F_b(u,v) \) by applying inverse DCT as follow

\[
f_b(x,y) = \alpha(u) \alpha(v) \sum_{m=0}^{M-1} \sum_{n=0}^{N-1} F_b(u,v) \cos \left( \frac{(2x+1)\pi m}{2M} \right) \cos \left( \frac{(2y+1)\pi n}{2N} \right)
\]

for \( x = 0, 1, 2, \ldots, m-1 \) and \( y = 0, 1, 2, \ldots, n-1 \) where \( \alpha \) is defined in Eq. 2.

The block based DCT yields three frequency sub-bands namely low frequency sub-band, middle frequency sub-band and high frequency sub-band. The low frequency sub-band generally contains more important or salient visual information. The high frequency sub-band is less significant and ignored for compression purpose. In general for devising the DCT based watermarking scheme, the mid-frequency sub-band is considered as because the modification of the coefficients of this band have comparatively less impact on the visual quality of the image and the watermarking scheme can easily resist the image compression attack [5].

Singular Value Decomposition (SVD)

The singular value decomposition is another efficient and popular tool for image transformations. The SVD of a given image \( f \) in the form of a matrix of dimension \( M \times N \) is defined as

\[
f = UDV'
\]

(4)

where \( U \) is an column orthogonal matrix of dimension \( M \times k \) whose columns are the eigenvectors of \( ff' \), \( D \) is a diagonal \( k \times k \) matrix that contains \( k \) singular values \( d_1, d_2, \ldots, d_k \) in descending order of magnitude, and \( V \) is also a column orthogonal matrix of dimension \( N \times k \) whose columns are the eigenvectors of \( f'f \). Here \( k \) denotes the rank of the matrix \( f \).

In the context of devising watermarking schemes based on SVD have gain lots of interest by several researchers because the SVD of an image does not change significantly when a small interference is added with this image [6] and also it has been found that the watermark embedding based on modification of singular values of the cover image has less affect on the visual quality of the watermarked image. So SVD is one of the popular choices for devising robust watermarking scheme.
CONCLUSIONS AND FUTURE SCOPES

In this paper, the proposed hybrid DCT-SVD is not only robust but also effective in retaining imperceptible property of the watermarked image. Experimental results show that the proposed scheme achieved the satisfactory results in terms of visual quality of the watermarked image and robustness against various image processing/manipulation attacks. In the proposed scheme insertion of the watermark into the reduced DCT transformed cover image helps effectively to resist the most common watermarking attacks like JPEG compression. In this paper, robustness of the proposed scheme is tested under some common image processing attacks. In future, our primary target would be to make the scheme more robust against different types of attacks on the watermarked image. It is also to mention that not only DCT-SVD based watermarking but also using various transformation technique like DCT-Walsh Transform-DWT-SVD etc. in hybrid manner can produce robust watermarking scheme.

REFERENCES