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Image Watermarking Based On DWT, DCT and SVD Techniques

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Abstract: ***Digital watermarking is a technique used for the information of the images that provides security for the confidentiality. The repetitions of the multimedia objects (i.e. audio, video, text, etc.) have been protected by some of the developed digital watermarking techniques. In this paper, we propose discrete wavelet transform (DWT), discrete cosine transform (DCT) and singular value decomposition (SVD) to protect duplication of digital media efficiently and used for digital watermarking images. SVD is applied to the approximate and the vertical coefficient of wavelet transform improves image protection in terms of PSNR and MSE between original and watermarked images. Experimental results show that the proposed algorithm give good imperceptibility for images and provides a watermarked images with good quality.***

Keywords: *Watermark, DWT, DCT, SVD, PSNR and MSE.*

1. Introduction

In the present globalization, the presence of the Internet and many image processing tools opens up to a greater degree, the downloading possibility of an image from the internet, altering it without the permission of the authorized person. For this reason and many others, image authentication has become an active and also a vital research area. In signals and images the embedding of watermark may cause alteration in them. Digital watermarking stands for embedding a signature signal, called watermark into a digital cover image, in order to confirm ownership, verify faithfulness or integrity of the cover, and it may also related to the audio, images, video or text. Digital watermarking is a process of embedding labels into digital cover image. These implanted marks are typically invisible that are later be detected or extracted. In general, watermark should satisfy some of the requirements which are listed below:

i) Imperceptibility: The quality of the original image should not be affected by the watermark, thus it should be invisible/inaudible to the human eyes/ears.

ii) Security: The watermark must be secreted and it should be detected by the authorized person.

iii) Capacity: The number of bits that can be embedded in one second to the host image.

iv) Invisibility: The embedded watermark should not be visible.

v) Readability: A watermark should provide more information and it should be undetectable. And to identify the ownership and copyright we can use the retrieval of the digital watermark.

In general, watermark has two groups: Spatial domain, in which embedding of watermark is directly done on pixel locations. In transform domain, a mathematical transform is used to embed watermark into the host image, later apply inverse transform to get the embedded image. Some of the common techniques are discrete wavelet transform (DWT), discrete cosine transform (DCT) and singular value decomposition (SVD).

In this paper, DWT, DCT and SVD watermarking techniques used for embedding watermark into the host image. A watermarking algorithm based on these three techniques results in good imperceptibility and visibility.

2. Related work

In [1], the application for watermark is protecting intellectual property rights. Based on non-overlapping DWT and SVD the watermarking scheme with circulation is presented. The DWT and SVD are applied to the host image and watermark image which is divided into non overlapping blocks. The scrambling watermark is embedded into the singular value matrix of original components with circulation. Extracting any consecutive four rows and columns from the blocked watermarked image can get complete watermark information. Digital products are easy to copy and modify so to protect the copyright of digital products has become a greater challenge. Digital watermark is an effective for copyright protection.

In [2], Hybrid watermarking scheme for digital images based on SVD. In this, the copyright protection is provided by embedding the components of watermark into DCT and DWT domain of host image. The watermarking technique embeds the information of image which is not easily identified by the others. The embedded watermark becomes invisible. The quality of watermarking and robustness are depends on the percentage of watermark that is embedded into host image. This includes some disadvantages like, some diagonal line problem occurs, and it gives less PSNR and gives less correlation coefficient.

In [3], for image copy right protection a hybrid watermarking scheme is presented based on Redundant DWT and SVD. With the help of high speed internet it is possible to transfer multimedia objects but transferring such objects may be modified by the attackers so this brings a problem called ownership problem. To overcome from this problem digital watermarking technique was proposed. In this SVD is a widely used technique but implementing it is very costly. Another commonly used watermarking technique is DWT. But the drawback is shift variant occurs due to down sampling of its bands that leads to a minor difference in input image and major difference in wavelet coefficients. This results in improper extraction of host and watermark image.

In [4] the watermark is personalized to JPEG2000 that is using two algorithms which modifies the wavelet coefficients of the LH2 band of host image. But it introduces only nominal differences between the watermarked image and original image.

In [5], the discrete wavelet transforms technique, in which they used binary marks to the two watermarks such as LL2 and HH2 respectively. That results in a mark which is robust against compression and weak robust against cropping and rescaling.

In [6], watermark embedding and extraction techniques are used in detection of the utilization of original image. The original image is input in detection algorithm with watermarked image. Detectors can detect the watermark in images that are modified in many ways but they cannot combine with the automatic watermark searching in digital image. Watermark embedding may done in spatial domain or in transform domain. In some algorithms imposed changes take into account the local image characteristics and properties of the human visual system that obtain watermarks are guaranteed to be invisible.

3. Digital watermarking

3.1 Discrete Wavelet Transform

DWT is a mathematical function in which an image hierarchically decomposes; it is also called as multilevel decomposition. It is usually used in variety of applications, such as signal processing applications in which noise is removed from audio and compression of audio and video. This wavelet transform decompose an image into four sub bands (LL, HL, LH and HH). Where L is low pass filter and H is high pass filter. LL is a low frequency part that represents approximate details of an image. HL, LH and HH are high frequency parts, where HL gives horizontal details, LH gives vertical details and HH gives diagonal details of an image. In this most of the important information is stored in the high amplitude of the signal and less important information appears in low amplitude of the signal. Discarding of the low amplitude will result in data compression. This method also focuses in embedding insight to improve the performance of watermarked image.

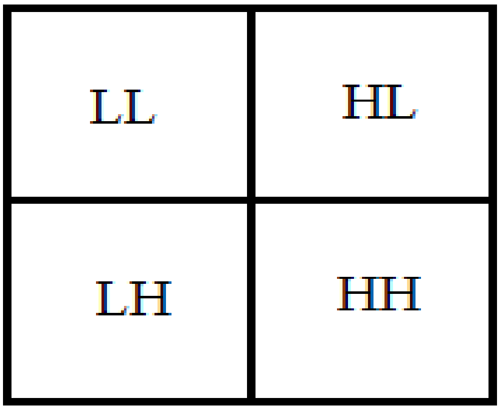


Figure 1: Single level DWT

These all sub bands having same bandwidth and creating a multi resolution viewpoint. Because of this advantage the watermark can be embed in any part of the frequency bands.

3.2 Discrete Cosine Transform

DCT is a technique that converts a signal from spatial domain to frequency domain. The matrix of 2- dimensional DCT gives the frequency coefficients in other form of matrix. The left topmost corner of the matrix gives the lowest frequency coefficients, where the right bottom most gives highest frequency coefficients. DCT in watermarking is divided in two parts, Global DCT and Block DCT. In global DCT, the transform is applied to all part of image. In block DCT, an image is segmented in non-overlapping blocks and DCT is applied in each block. Applying DCT on image gives 3 coefficient bands, low frequency band, mid frequency band and high frequency band. But embedding the watermark is easily done in mid frequency band because, the watermark is embedded by modifying the coefficients of the middle frequency sub band so that the visibility of the image will not be affected and watermark will not be removed. Two main facts of DCT are, one is most of the signal energy is in low frequency band which has important part of image and second is high frequency components of image are removed by compression. The two-dimensional DCT is usually used in digital image processing. Given an image *A* of size *N*×*N*, the DCT of the image is defined as:

$$C(u,v) = \propto(u) \propto(v) \sum_{x=0}^{M-1} \sum_{y=0}^{N-1} f(x,y) \times$$

$$\cos\left[\frac{\pi(2x+1)u}{2M}\right] \cos\left[\frac{\pi(2y+1)v}{2N}\right] \quad \text{....... (1)}$$

And, the inverse transform is

$$f(x,y) = \sum_{u=0}^{M-1}\sum_{v=0}^{N-1} \propto(u) \propto(v) C(u,v) \times$$

$$\cos\left[\frac{\pi(2x+1)u}{2M}\right] \cos\left[\frac{\pi(2y+1)v}{2N}\right] \quad \ldots\ldots (2)$$

Where,

$$\propto(u) = \begin{cases} \frac{1}{\sqrt{M}}, u = 0 \\ \sqrt{\frac{2}{M}}, \quad u = 1,2,\ldots,M-1 \end{cases}$$

$$\propto(v) = \begin{cases} \frac{1}{\sqrt{N}}, v = 0 \\ \sqrt{\frac{2}{N}}, \quad v = 1,2,\ldots,N-1 \end{cases}$$

3.3 Singular Value Decomposition

SVD is one of the tools to analyze the matrices. In watermarking, SVD is applied to the image then the watermark is resided by altering singular values. This SVD technique is used to find the SVD of an image and modifying the singular value to embed the watermark. In SVD transformation, a image is decomposed into three matrices which are of same size. In the perspective of linear algebra, a image is of nonnegative scalar entries which is considered as a matrix. Consider A as a square image, written as $A \in R^{n \times n}$, where R is real number province. Then SVD of A is given as $A = USV^T$, where U and V are orthogonal matrices and S is diagonal matrix as

$$S = \begin{bmatrix} s_1 & 0 & 0 & 0 \\ 0 & s_2 & 0 & 0 \\ 0 & 0 & s_{n-1} & 0 \\ 0 & 0 & 0 & s_n \end{bmatrix}$$

S's are singular value which satisfies

$$s_1, s_2, \ldots s_{n-1}, s_n \geq 0$$

4. Proposed methodology

In proposed watermarking method, we have used DWT, DCT and SVD techniques. Here, we have presented an adaptive scheme to embed a watermark image into a larger host image by using these techniques. In below section we have presented the flow diagram for watermark embedding and also for the watermark extraction. This gives detailed procedure for embedding of watermark into host image and extracting watermark from watermarked image.

4.1 Watermark embedding

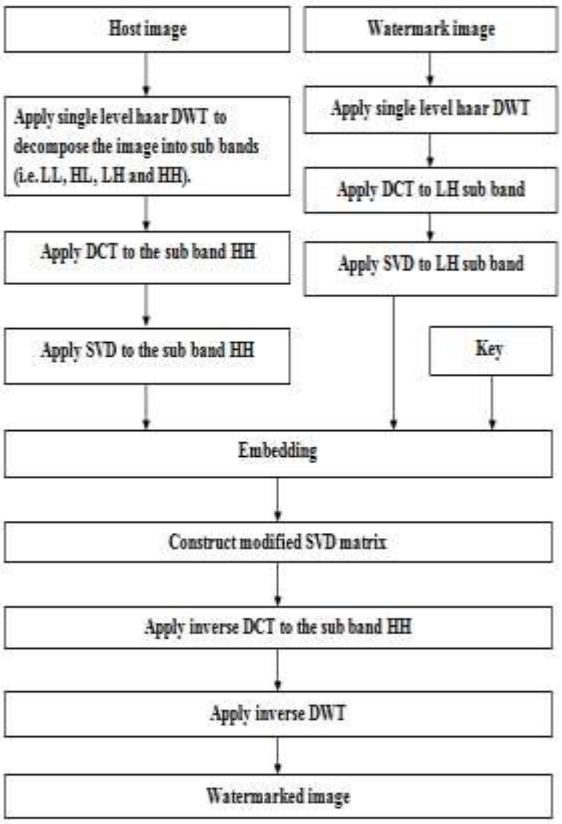


Figure 2: Flow diagram for watermark embedding

4.1.1 Algorithm: Watermark embedding

Step 1: Select a host image HI.

Step 2: Apply single level haar DWT to decompose host image into four sub bands i.e. LL, HL, LH and HH.

Step 3: Select a high band HH and apply the DCT to on that high band HH.

Step 4: Apply SVD to the high band HH to get singular value S.

Step 5: Input a watermark image wi. Apply double level haar DWT to decompose it into four bands LL1, HL1, LH1 and HH1.

Step 6: Select the high band LH1 of wi. Apply DCT to high band LH1.

Step 7: Apply SVD to high band LH1 to get singular value S_3.

Step 8: Modify the singular value S, by using equation $S_2 = S + \alpha \times S_3$.

Step 9: Construct the modified SVD matrix HH11.

Step 10: Apply inverse DCT to the high band HH11. And apply inverse DWT along with LL, HL and LH.

Step 11: Finally we get the watermarked image WI.

4.2 Watermark extraction

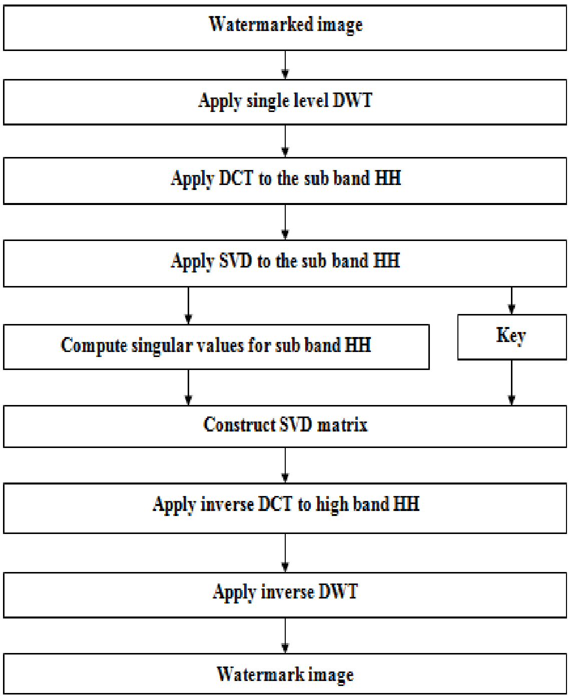


Figure 3: Flow diagram for watermark extraction

4.2.1 Algorithm: Watermark extraction

Step 1: Input watermarked image WI.

Step 2: Apply single level DWT to decompose it into four sub bands LL*, HL*, LH* and HH*.

Step 3: Select the high band HH* of WI. Apply DCT to it.

Step 4: Then apply SVD to the high band HH* to get singular value S*.

Step 5: Modify the S* by using the equation
$S_3 = (S_2 - S)/ \alpha$.

Step 6: Construct the modified SVD matrix HH1*.

Step 7: Apply inverse DCT to the high band HH1*.

Step 8: Apply inverse DWT to all bands to get watermark image.

5. Experimental results

In the proposed watermarking algorithm the host image is of size 512×512 is taken as an input to the system, which is then converted to the size of 256×256. A monochrome watermark image of size 256×256 is used for further process. The proposed watermarking algorithm is simulated in MATLAB 12a. The proposed watermarking algorithm tested on various host images and watermark images and the results are given for LEENA, BARBARA, HOME, BOAT and BABOON. The original images are shown in fig 4(a), fig 5(a), fig 6(a), fig 7(a) and fig 8(a). Watermarked images are shown in fig 4(b), fig 5(b), fig 6(b), fig 7(b) and fig 8(b). Figure 9(a) is used as watermark image.

(a) Original (b) Watermarked

Figure 4: Grayscale image Leena

(a) Original (b) Watermarked

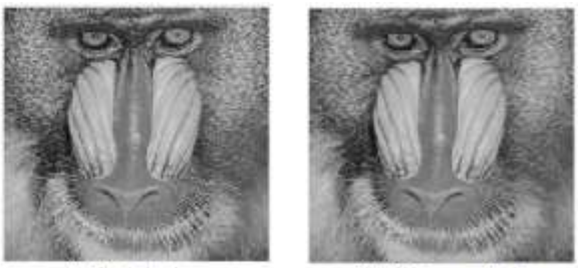
Figure 5: Grayscale image Barbara

(a) Original (b) Watermarked

Figure 6: Grayscale image Home

(a) Original (b) watermarked

Figure 7: Grayscale image Boat



(a) Original (b) Watermarked

Figure 8: Gray scale image Baboon

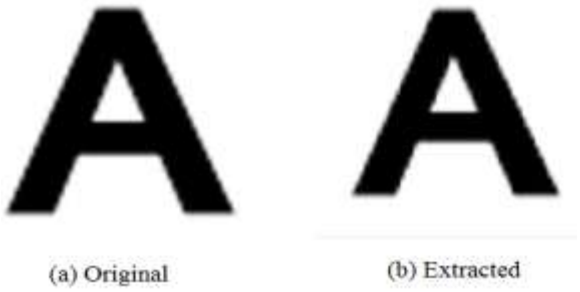


Figure 9: Watermark image

The performance evaluation is also carried out for the proposed method. The evaluation metrics used are PSNR (Peak Signal-to-Noise Ratio) and MSE (Mean Square Error). PSNR usually used to measure the imperceptibility between host image and watermarked image. The PSNR is calculated using equation 3. The lower value of the MSE, lower the error. The MSE is calculated using equation 4. The higher value of the PSNR, better the quality of the image. Some of the PSNR and MSE values are shown in below table 1.

$$PSNR = 10\log_{10}\left(\frac{R^2}{MSE}\right) \quad \text{....... (3)}$$

$$MSE = \frac{1}{mn}\sum_{0}^{m-1}\sum_{0}^{n-1}\|f(i,j) - g(i,j)\|^2 \quad \text{....... (4)}$$

Table 1: Different PSNR and MSE values for different images

Image	*MSE*	*PSNR*
Leena	0.000153	38.15
Barbara	0.000555	32.55
Home	0.000439	33.56
Boat	0.000396	34.02
Baboon	0.000782	30.75

6. Conclusion

In this paper, three watermarking techniques DWT, DCT and SVD have been used. In the image watermarking, the useful implementation of image with respect to embedding the watermark into host image using the DWT, DCT and SVD are most significant part to achieve imperceptibility and better visibility. Therefore the proposed algorithm provides the good quality of watermarked image. Higher PSNR results in better quality of image. Lower MSE results in low errors.

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