COMPARISON OF DIFFERENT DIGITAL WATERMARKING TECHNIQUE FOR CONTENT AUTHENTICATION

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Abstract— Digital watermarking is one of the effective methods for preventing illegal copyright of digital media. It is the process of hiding digital data in any form of multimedia data such as image, audio, video, etc. This paper performs a comparative analysis of different image watermarking techniques. The watermarking techniques based on DCT and SVD, DWT and SVD and a combination of DCT and DWT is implemented. The DCT+DWT method is also experimented by dividing the cover image and watermark into four equal parts and then performing the embedding technique. Different attacks are applied on the watermarked image in order to analyse the robustness of each algorithm.

Keywords— Watermark; Discrete Cosine Transform (DCT); Discrete Wavelet Transform (DWT); Singular Value Decomposition (SVD); Robustness

I.INTRODUCTION

Digital watermarking is the method of embedding digital information in any form of multimedia data such as image, audio, video, etc[17]. This method is a variation of steganography, which is a method of hiding [13] one secret message in another message. In earlier days watermarks were used as trademark or logo for indicating the ownership of a specific product. For example, the logo of an animation company will be embedded in the video developed by that company; the name of the person who took the photograph will be watermarked in the photograph. Watermarks are also used for copyright protection of multimedia data. We can see watermarks in currencies, paper and postage stamps in order to prevent fraud and forgery.

Today, the use of Internet has lead to the increased transfer of multimedia data, especially images, through the network. At the time of transmission this data may get affected by noise, or some third party tries to get that data and tamper it. This can be prevented using digitalwatermarks. The sender who wants to send secret or confidential image to some other person will embed the secret image in another image called cover image with the help of a key and send it through the Internet. The receiver will receive that image and extracts the hidden watermark from that image with the help of the shared key. The watermark will have distortions or some changes if it was attacked and tampered at the transmission time. This is the whole process of imagewatermarking. Digitalwatermarking has wide range of applications in the field of computer science, cryptography.

Researches are happening widely in the field of watermarking to find out the best watermarking algorithm which gives the most robust watermark. Watermarks can be visible and invisible [19]. Invisible watermarks are used for copyright protection and secret message passing. Different watermarking techniques have been developed so far.Watermarks can be embedded in spatial domain and frequency domain. Frequency domain methods are more efficient and robust compared to spatial domain methods.

Different image watermarking algorithms are developing day by day. Most of them are frequency domain methods. Likewise; new ways for attacking the watermarked images at transmission time are also developing. So it is important to find out the best watermarking method. The commonly used frequency domain methods are based on DCT and DWT. So the problem statement is to find out which watermarking algorithm DCT and DWT is more efficient and also to analyse the robustness of a method which is the combination of DCT and DWT.

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The paper is organized as follows: Section II covers the related works based on frequency domain watermarking, section III, IV, V and VI defines the proposed watermarking techniques DCT,DWT,DCT+DWT and DCT+DWT by dividing the images, respectively. Section VII defines experimental results after applying attacks on the image and VIII gives the conclusion drawn from the analysis.

II. RELATED WORK

Watermarking techniques based on spatial domain was developed first. They are easy to implement and less complex in Shyndel proposed a spatial domain Watermarking technique called LSB watermarking. The Least Significant Bit of the binary converted pixel value of the host image is selected and it is replaced by the pixel of the watermark image. So that a third party cannot view the watermark. The watermark is embedded at the LSB of the host image. But the spatial domain methods are considered to be less robust. As a result frequency domain methods were developed.

Another method proposed by F.Namaziis an improved block-based DCT method in which the watermark is applied to the middle frequency components of the DCT transformed host image. Mid frequency was selected in order to achieve robustness and high transparency. This method is more robust against compression attacks. The image is divided into different blocks and then DCT is applied to each block. Then, mid-frequency components with high frequency are selected and the watermark is embedded to the selected frequencies.

Methods based on the singular values and watermarking using them was also developed. SVD of an image will give the dominant pixels in the image. Chin-Chin Lai proposed SVD-based watermarking technique. This method uses Human Visual Characteristics of the image to find out at which portion the watermark is to be embedded.

Another method based on frequency domain is the watermarking in the DWT domain. The method proposed by GauravBhatnagar decomposes the host image using DWT. A reference image is formed and it is saved for using at the time of extraction. SVD [20] is applied to both reference image and the watermark [18].

Then, the singular values of the reference image are modified using singular values of the watermark. To reconstruct the watermarked image, inverse DWT is applied. DWT[14] transforms an image in the spatial domain to frequency domain by dividing it into different frequency sub bands which are LL, HH, LH and HL.

L.Sumalatha proposed a new method based on checksum to embed watermark into a digital image. Block Based Content Checksum Watermarking (BCCW) method is a watermarking technique developed in order to address tampering attacks. The image is divided into 4×4 sub-blocks and again divided into 2×2 blocks. The checksum is computed for each 4×4 blocks and then the checksum is placed in selected 2×2 sub-blocks.InMandeep Singh Saini has done a comparative study on different watermarking techniques which are DCT, DWT and DCT+DWT. In each method, the cover image is resized into 256×256 and divided into 8×8 blocks. On these blocks, transformation is applied and on that the watermark is applied and finally, inverse transformation is done. From the calculated PSNR and NC values DCT+DWT method is found to be robust.

From these we can see that different image watermarking techniques exists and the robustness of each of the method varies. So it is important to find out which method is more robust. This paper presents a comparative analysis of four image watermarking techniques based on frequency domain.

III.DCT-SVD WATERMARKING TECHNIQUE

In this method the DCT of the cover image and the watermark image is taken. Then, SVD is computed for the cover image and the watermark. Then, the singular values of the watermarked image are found out by adding the singular values of the watermark with the singular values of the cover image.

A. Watermark Embedding:

The block diagram for DCT-SVD watermarking is given in Figure 1.

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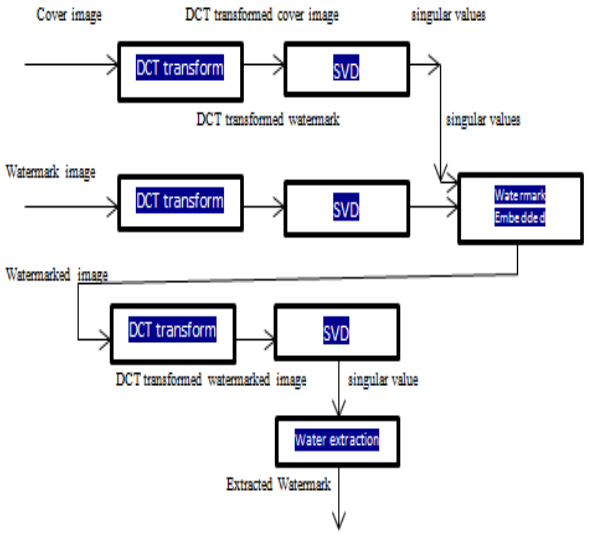

Figure 1: DCT-SVD watermarking

1. The cover image is taken and DCT transformation is performed on it.
2. From that DCT transformed image the pixels to which the watermark is applied is found out by extracting the singular values from the cover image.

For that, Singular Value Decomposition (SVD) of the image is taken.

$$I \text{ SVD } U_1 * V_1 * V_1^T \quad (1)$$

3. Perform DCT on the watermark image.
4. Perform SVD on the watermark image to get the singular values.

$$W \text{ SVD } U_W * V_W * V_W^T \quad (2)$$

5. The singular values from the watermark image are Embedded at the singular values in the cover image by using equation (3) in which k is the strength Factor.

$$S \square I \text{ SVD} k * W \text{ SVD} \quad (3)$$

6. Perform inverse SVD using (4)

$$W \text{ SVD } \square U \, I * S * V \, I \quad (4)$$

7. Perform inverse DCT to get the watermarked image.

B. Watermark Extraction

It is the reverse process of watermark embedding.

1. Perform DCT on the original image.
2. Perform SVD on the original image to get the singular values.

$$I \text{ SVD } \square U \, I * S \, I * V \, I \, T \quad (5)$$

3. Perform DCT on the watermarked image.
4. Perform SVD on the watermarked image to get the singular values using (6).

$$W \square \text{SVD} \square U \, W \square * S \, W \square * V^T \quad (6)$$

5. Find out the singular values for the original image using (7) where k is the watermark strength factor.

$$S_W \square (S_W \tilde{S}_W \square) / k \quad (7)$$

6. Perform inverse SVD

$$W \text{ SVD } \square U \, W * S \, W * V^T \, W \quad (8)$$

7. Perform inverse DCT to get the watermark image.

IV. DWT-SVD WATERMARKING TECHNIQUE

In DWT-SVD method the cover image is divided into different frequency sub-bands and the SVD of the low-frequency sub-band is taken. The watermark is embedded in the low frequencies of the cover image. The embedding and extraction procedure is explained below and the block diagram is shown in Figure 2.

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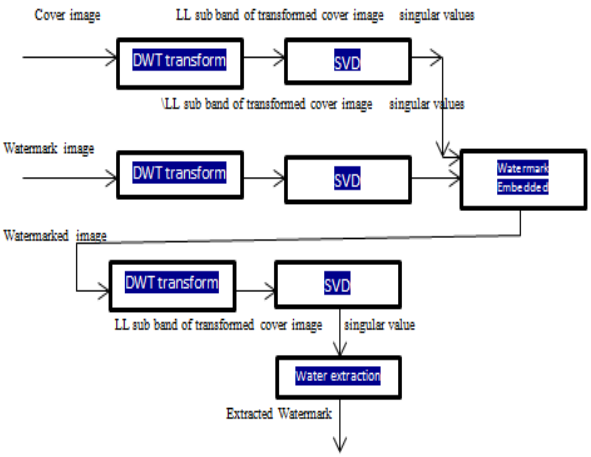

Figure 2: Block diagram for DWT-SVD Watermarking

A. Watermark Embedding

1.Perform DWT on the cover image and divide the image into LL, LH, HL and HH sub-bands

2. Perform SVD on the LL sub-band to get the singular values using (9).

$$ILL_{SVD} \square U_{ILL} * S_{ILL} * V^{T} \qquad (9)$$

3. Now perform DWT on the watermark image and divide the image into LL, LH, HL and HH sub-bands.

4. Perform SVD on the LL sub-band to get the singular values

$$WLL\ SVD \square U\ WLL * S\ WLL * V^{T}WLL \qquad (10)$$

5. Find out the singular values for the watermarked image using (11) where k is the watermark strength factor.

$$S \square S_{ILL}k * S_{WLL} \qquad (11)$$

6. Perform inverse SVD

$$W\ LL\ SVD \square U\ ILL * S * V^{T}ILL \qquad (12)$$

Perform inverse DWT to get the watermarked image.

B. Watermark Extraction

1. Perform DWT on the original image and divide into LL, LH, HL and HH sub-bands.

2. Perform SVD on the original image to get the singular values

$$ILL\ SVD \square U\ ILL * S\ ILL * V^{T}ILL \qquad (13)$$

3. Perform DWT on the watermarked image and divide into LL, LH, HL and HH sub-bands.

4. Perform SVD on the watermarked image to get the singular values.

$$W \square L\ SVD \square U\ W \square L * S\ W \square L * V^{T}W \square L \qquad (14)$$

5. Find out the singular values for the resultant original Image using (15) where k is the watermark strength factor.

$$S\ WLL \square (S\ WL\tilde{L}S\ ILL) / k \qquad (15)$$

6. Perform inverse SVD

$$WLL \square S * S_{WLL} * V^{T}_{WLL} \qquad (16)$$

7. Perform inverse DWT to get the watermark image.

V. DCT-DWT WATERMARKING

This method is a combination of both DCT and DWT. Both the transforms DCT and DWT are used for embedding the watermark. The block diagram for watermarking process is shown in Figure 3

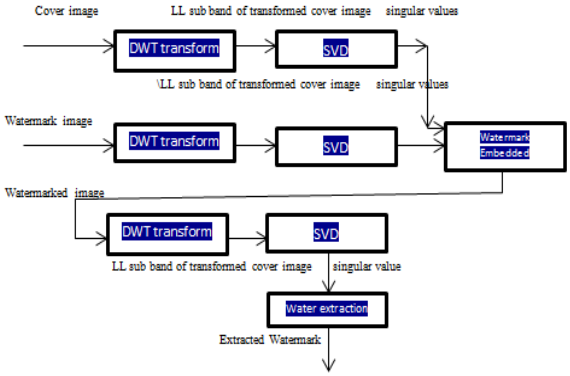

Figure 3: Block diagram for DCT+DWT Watermarking

1. Perform DCT on the cover image.

2. Perform DWT on the DCT converted cover image And divide the image into LL, LH, HL and HH sub-bands.

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3. Perform SVD on the LL of the image.

$I_{SVD} \quad U_I * S_I * V_I^T$ (17)

4. Perform DCT on the watermark image.

5. Perform DWT on the DCT converted watermark and divide the image into LL, LH, HL and HH sub- bands.

6. Perform SVD on the LL of the image.

$$W_{SVD} = U_W * S_W * V_W^T \quad (18)$$

7. Find out the singular values for the watermarked Image.

$$S = S_W + k_W * S_W \quad (19)$$

8. Perform inverse SVD

$$W_{SVD} = U_I * S_W * V_I \quad (20)$$

9. Perform inverse DWT.

10. Perform inverse DCT to get the watermarked image.

B. Watermark Extraction

1. Perform DCT on the original image.

2. Perform DWT on the DCT converted original Image and divide the image into LL, LH, HL and HH sub-bands.

3. Perform SVD on the LL of the image.

$$I_{SVD} = U_I * S_I * V_I^T \quad (21)$$

4. Perform DCT on the watermarked image.

5. Perform DWT on the DCT converted watermarked image and divide the image into LL, LH, HL and HH sub-bands.

6. Perform SVD on the LL of the image.

$W_{SVD} \quad U_W * S_W * V_W^T$ (22)

7. Find out the singular value of watermark images.

$$S_W = (S_{\tilde{W}} - S_I)/k \quad (23)$$

8. Perform inverse SVD

$$W_{SVD} = U_W * S_W * V_W^T \quad (24)$$

9. Perform inverse DWT and then inverse DCT to extract the watermark.

VI. DCT+DWT WATERMARKING BY DIVIDING THE IMAGE

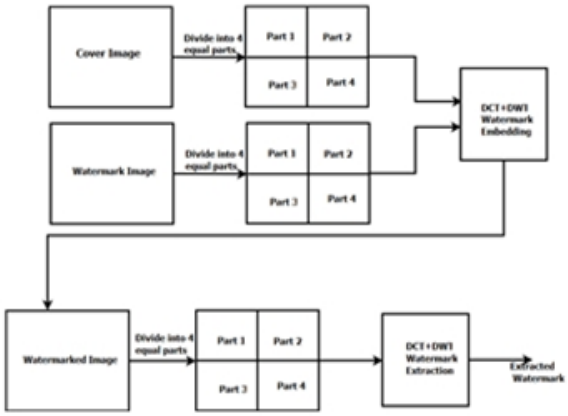

Figure 4: Watermarking process after dividing the image

In this method, the embedding technique is same as In DCT+DWT method. But here, the cover image and the watermark are divided into four equal parts and then the watermark is embedded in each part separately and finally, the parts are recombined to get the watermarked image. The process is shown in Figure 4.

A. Watermark Embedding

1. Divide the cover image into four equal parts.

2. Divide the watermark into four equal parts.

3. Embed the one divided portion of the watermark in The corresponding divided portion of the cover Image using DCT+DWT method.

4. Recombine the divided parts to get the watermarked image.

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B. Watermark Extraction

1. Divide the original image into four equal parts.
2. Divide the watermarked image into four equal parts.
3. Extract the portions of watermarks which areembedded, from the portions of the dividedwatermarked image using the DCT+DWTextraction process.
4. Recombine the extracted portions to get the watermark.

VII. EXPERIMENTAL RESULTS

We have experimented the four watermarking algorithm on 10 different cover images and a single image is used as common watermark (shown in Figure 6). One such cover image is shown in Figure 5.

Figure 5: Cover image

Figure 6: Watermark

The robustness of DCT, DWT, DCT+DWT and the DCT+DWT method after dividing the image is analysed by calculating the Peak Signal to Noise Ratio (PSNR) ,Normalized Correlation (NC), Similarity Index (SI) [21] values after attacking the watermarked image. The attacks applied are rotation (5º), scaling (5), shearing (5) and noise (0.02) [15]. The results for the Lena image are shown in Tables I, II and III.

Attacks	DCT	DWT	DCT+DWT (without dividing image)	DCT+DWT (with dividing image)
Rotation	12.27	24.19	41.6157	34.7910
Scaling	14.089	39.9674	63.770	46.5709
Shearing	21.974	41.238	25.885	22.8546
Noise	4.12	4.1782	23.176	50.6715

TABLE I. RESULTS AFTER ATTACKING THE WATERMARKED IMAGE (PSNR VALUES IN DB)

Attacks	DCT	DWT	DCT+DWT (Without dividing image)	DCT +DWT(With dividing image)
Rotation	0.9606	0.9617	0.9458	0.8216
Scaling	0.8582	0.8915	0.9809	0.9601
Shearing	0.2759	0.9196	0.5203	0.7197
Noise	-0.4437	-0.4232	0.4593	0.9235

TABLE II. RESULTS AFTER ATTACKING THE WATERMARKED IMAGE (SIVALUES IN DB)

VIII. CONCLUSION

In this paper, different watermarking algorithms which are based on DCT, DWT and DCT+DWT are implemented and are compared with each other to find out which method is more robust against different attacks. The DCT+DWT method is applied directly to the image and the same technique is applied after dividing the cover image and watermark into four.

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The experimental results shows that DCT+DWT method applied directly into the image is more robust, since it gives high PSNR, NC and SI values compared to others. But, after dividing the images and then applying the same method do not give much better results except in the case of noise. The embedding done after dividing the image will give better results for noise attacks only. The DWT method is the second best technique. The watermark is highly affected by noise attack in each of the methods and the watermark is less affected by shearing attacks.

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Normalized Correlation (NC) [1

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