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A VEDIO WATERMARKING SCHEME USING SECOND LEVEL DISCRETE WAVLETTRANSFORMATION (DWT) AND FAST FOURIER TRANSFORMATION (FFT)

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Abstract-*In this work, a video watermarking technique based on Discrete Wavelet Transformation (DWT) and Fast Fourier Transformation (FFT) is proposed. The proposed watermarking scheme does not require the original host video during extraction process. Here selected frames of the video are decomposed using second level DWT. Then LL2 band is divided into non overlapping pixel blocks and selected blocks are transformed using FFT. The watermark is inserted into the high frequency component of the transformed blocks. After watermark insertion, inverse FFT and DWT is used to obtain watermarked frame. Using these frames watermarked video is constructed. The extraction process reverses the embedding process without the original video. Compared with other watermarking approach, experimental result shows that the proposed method produces robust watermark against different types of attack.*

Keywords: Discrete Wavelet Transformation (DWT); Fast Fourier Transformation (FFT)

1. INTRODUCTION

With the expansion of the World Wide Web (www) distribution of digital information such as image, video, audio has increased exponentially. So, copyright protection of this information has become an important issue. There are many ways to provide copy right protection and owner authentication of digital data and Watermarking is one of them.

Watermarking is the process of embedding information called watermark within a digital data so that it can later be extracted and used for various purposes. The information is embedded in such a way that it doesn't cause any visual degradation to the host media. So the embedded watermark is imperceptible to the user. Video watermarking is the process of embedding information within a video file. Video watermarking is much similar to image watermarking. The main difference is video watermarking embeds watermark in a sequence of images instead of one. There are three important issues of the watermarking system. First, imperceptibility, meaning watermark should be perceptually invisible to maintain its secrecy. Second, robustness, watermark should be robust enough to resist common image processing attacks. Third, blindness, the watermark can be extracted without the original host media. These factors determine the quality of the watermarking scheme.

Watermarking scheme can be classified into several categories based on their application, embedding domain and characteristics. Based on embedding domain, watermarking scheme can be classified into two categories, spatial domain and frequency domain. In spatial domain watermark is embedded by manipulating the intensity and luminance value of the pixels [1,2]. In frequency domain, frequency coefficients are modified to embed watermark. Frequency domain watermark algorithm typically uses Discrete Cosine Transformation (DCT), Discrete Wavelet Transformation (DWT), Discrete Fourier Transformation (DFT), Singular Value Decomposition (SVD) [3-10]. Spatial domain watermarking schemes are simple and embedding capacity is high. But they produce weak watermark. On the other hand, watermarking algorithm based on frequency domain produces more robust watermark. There is no single algorithm exist which can withstand all image attack. So, there is scope of improvement in the existing algorithms. Such an attempt is made in this paper.

Lin *et al*. [7] proposed an algorithm based on DWT. Here a binary watermark of size 32×32 is embedded in a gray scale host image of size 512×512. Host image is first decomposed using fourth level DWT and then LH4 band is divided into blocks and then watermark is embedded. Limitations of this method include low data embedding capacity. Also adjusting parameter is difficult with the change of watermarking requirement or input image [12].

Another algorithm based on DWT with more scope of information embedding capacity was proposed by Lin *et al*. [13]. Here 8 bit gray scale image of 512×512 size is used as host and the watermark was a binary image of 32×32 size. For watermark insertion first the host image is decomposed by fourth level DWT. Fixed length blocks are constructed from LH4 and LH3 sub-band by including one coefficient from LH4 and four coefficients from LH3. One watermark bit is embedded in each block. This method allows up to 1024 bit of watermark to be embedded. It also allows easy adjustment of the scheme parameter with respect to change in requirement.

Q. Su *et al.*[14] proposed a color image watermarking algorithm in spatial domain using Singular Value decomposition. Here first the cover image and the watermark image is divided into its RGB components. Then to increase the security the watermark image is scrambled using Arnold transformation. R, G, B component of the host image is divided into 4×4 non overlapping blocks and blocks are decomposed using SVD. The watermark is embedded by changing the relation between the second ($u_{2,1}$) and the third ($u_{3,1}$) elements in the first column of u matrix.

Q. Su *et al.*[15] proposed another color image watermarking algorithm in spatial domain using QR decomposition. In this approach first the cover image is separated into its RGB component and divided into 4×4 non overlapping blocks. These blocks are then decomposed using QR decomposition. Watermark is embedded by quantifying the element in fourth column of first row(r_{14}) of R matrix.

K. Ramanjaneyul*et al.*[12] proposed a watermarking algorithm that uses third level DWT to decompose the cover image. Then LH2 and LH3 coefficients are grouped together to form different blocks. Grouping is done in such way that each block contains one coefficient from LH3 and four coefficients from LH2 sub-band. A distance vector is computed to indicate difference between first and second minimum in a block. To embed a watermark 0, first and second minimum of a block are assigned the same value which lies between first and second minimum. The exact value is selected using generic algorithm. To embed watermark bit 1, first minimum value is decreased by a value which is maximum among the mean values of the distance vector and constant. Generic Algorithm is used to choose the constant value. After embedding all watermark bits inverse DWT is applied to reconstruct the watermarked image.

2. LITERATURE REVIEW

2.1 Discrete Wavelet Transformation (DWT)

The basic idea of DWT in which a signal is divided in two parts one is high frequency part and another is low frequency part. Then the low frequency part is split into two parts and the similar process will continue until the desired level is reached. The high frequency part of the signal is contained by the edge components of the signal. In each level of the DWT (Discrete Wavelet Transform) decomposition an image separates into four parts these are approximation image (LL) as well as horizontal (HL), vertical (LH) and diagonal (HH) for detail components. In the DWT decomposition input signal must be multiple of 2^n. Where, n represents the number of level. To analysis and synthesis of the original signal DWT provides the sufficient information and requires less computation time. Watermarks are embedded in these regions that help to increase the robustness of the watermark. Figure 1 shows 3rd level DWT decomposition.

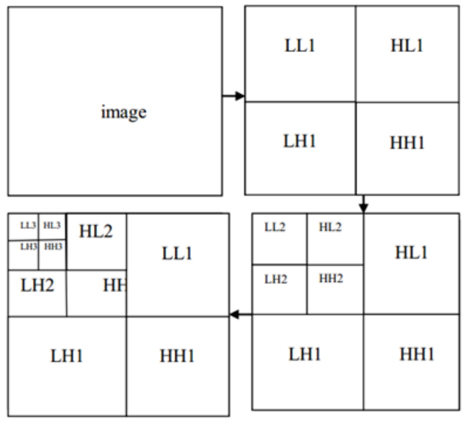

Fig.1: 3rd level DWT decomposition.

2.2 Fast Fourier Transformation (FFT)

The general idea is that the image f(x,y) of size M x N will be represented in the frequency domain F(u,v). The formula for the two-dimensional discrete Fourier transform (DFT) is given by Eq. (1).

$$F(u,v) = \sum_{x=0}^{M-1}\sum_{y=0}^{N-1} f(x,y)e^{-i2\pi(\frac{ux}{M}+\frac{vy}{N})} \qquad (1)$$

The concept behind the Fourier transform is that any waveform can be constructed using a sum of sine and cosine waves of different frequencies. The exponential in the above formula can be expanded into sines and cosines with the variables u and v determining these frequencies. The inverse discrete Fourier transform is given by Eq. (2).

$$f(x,y) = \frac{1}{MN}\sum_{u=0}^{M-1}\sum_{v=0}^{N-1} F(u,v)\, e^{-i2\pi\left(\frac{ux}{M}+\frac{vy}{N}\right)} \qquad (2)$$

The Fast Fourier Transform (FFT) is an algorithm to compute the discrete Fourier transform (DFT) and it's inverse. Fourier analysis converts time (or space) to frequency and vice versa; an FFT rapidly computes such transformations by factorizing the DFT matrix into a product of sparse (mostly zero) factors. As a result, fast Fourier transforms are widely used for many applications in engineering, science, and mathematics.

2.3 Image Entropy

Entropy of an image is the calculation of information contained within the image. Entropy is high where image packs most information. So near the edge area of image entropy is high. Human eye is less sensitive to changes in the high entropy region. Entropy can be calculated by using Eq. (3).

$$entropy = -\sum p_i log_2(p_i) \qquad (3)$$

Where p_i represents the pixel value

3. PROPOSED METHOD

Embedding and extraction process of the proposed frame work is given below.

3.1Embedding Process

Watermark embedding process consists of the following steps:
Step 1: Extract Frames from the host video.
Step 2: Select some frames for watermarking.
Step 3: Decompose the selected frames by second level two dimensional DWT.
Step 4: Select LL2 sub band and divide it into 8×8 pixel blocks.
Step 5: Select required number of blocks using entropy. Here high entropy blocks are selected for watermark embedding and a key is generated.
Step 6: Apply two dimensional FFT on the selected blocks.
Step 7: Shift the decomposed blocks using fft shift.
Step 8: Four watermark bits are embedded in each block. Embedding is done by modifying real and imaginary parts of the pixel value using the following equations: Suppose n^{th} pixel value is a+bi. Where a represents real part of the pixel value and b represents imaginary part of the pixel value. Mean between a and b is given by Eq.(4).

$$m = abs\left(\frac{a-b}{2}\right) \tag{4}$$

For watermark bit 0, imaginary part is made larger than the real part using Eq. (5) and Eq.(6).

$$a = a - m \tag{5}$$

$$b = (b + m) + k \tag{6}$$

Where k is a constant.

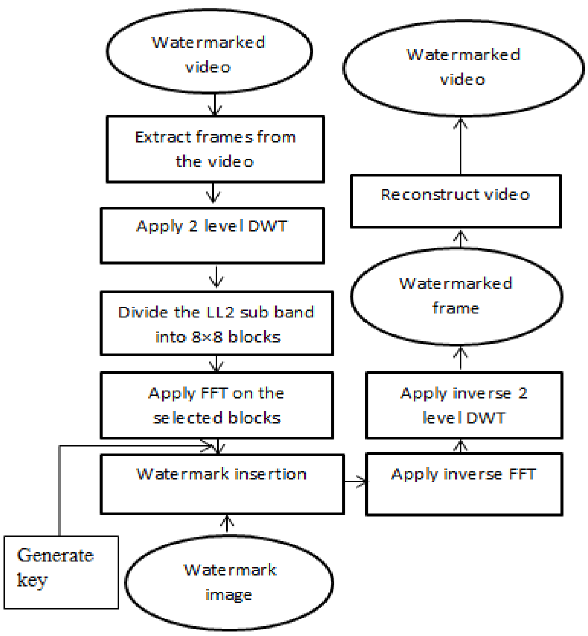

Fig.2: Watermark embedding process

For watermark bit 1, real part is made larger than imaginary part using Eq. (7) and Eq. (8).

$$a = (a + m) + k \tag{7}$$

$$b = (b - m) \tag{8}$$

Step 9: Apply inverse fft shift.
Step 10: Apply inverse FFT.
Step 11: Apply inverse DWT to reconstruct watermarked image.
Step 12: Reconstruct video using watermarked frames.
Figure 2 shows block diagram of watermark embedding process.

3.2 Extraction Process:

Watermark is extracted using following steps:
Step 1: Extract Frames from the host video.
Step 2: Select the watermarked frames.
Step 3: Decompose those frames by second level two dimensional DWT.
Step 4: Select LL2 sub band and divide it into 8×8 pixel blocks.
Step 5: Select required number of blocks using the key.
Step 6: Apply two dimensional FFT on the selected blocks.
Step 7: Shift the decomposed blocks using fft shift.
Step 8: Extract watermark from the decomposed blocks using following rules:
If real part is greater than the imaginary part of the pixel value then the watermark bit is 1.
Otherwise extracted watermark bit is 0.
Figure 3 shows block diagram for proposed watermark extraction process.

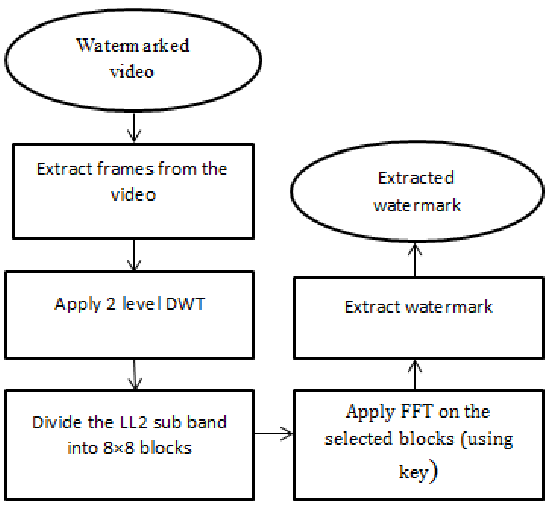

Fig.3: Watermark Extraction process.

4. EXPERIMENTAL RESULT

Figure 4 show simulation frames from different videos that are used as the host images and a binary image of 32×32 bit is used as the watermark image. Simulation results are used to analyze imperceptibility and robustness of the proposed algorithm.

Fig.4: Host image (a,b,c) and watermark image

Peak Signal-to- Noise (PSNR) ratio between the host image and the watermarked image, is used to determine the imperceptibility of the watermarked image. Equation (10) is used to calculate PSNR of an M×N image.

$$\text{MSE} = \frac{1}{M\times N}\sum_{i=1}^{M}\sum_{j=1}^{N}[I(i,j) - I'(i,j)]^2 \quad (9)$$

$$PSNR = 10\log_{10}((255\times 255) \div MSE) \quad (10)$$

Where MSE is Mean Square Error and *I(i,j)* is the host image and *I'(i,j)* is the watermarked image and calculated using Eq. (9). For color image, PSNR value can be calculated byEq. (11).

$$PSNR = \sum_{i=1}^{3}\left(\frac{PSNR_i}{3}\right) \quad (11)$$

Where i={1,2,3} represents PSNR of R, G, B component of the color image, respectively. Higher PSNR value indicates better imperceptibility. Figure 5 shows watermarked image and their PSNR value.

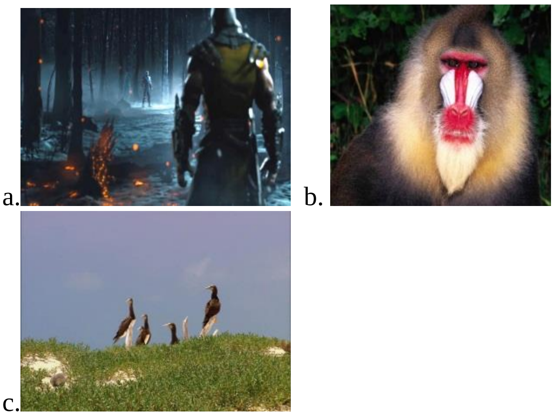

Fig.5: Watermarked images: a)PSNR=46.2730, b)PSNR=37.0628, c)PSNR=31.8466

Robustness of a watermarked image is determined by extracting watermark from attacked image and calculating Normalized Cross-Correlation (NCC) value. It is a small value ranging from 0 to 1. Higher value indicates more similarity between original and extracted watermark. Table 1 shows NCC value of extracted watermark after different types of attack.

Table 1:Simulation results

Attack type	**NCC value**
Salt & Pepper noise (0.001 density)	a. 1.0
	b. 1.0
	c. 0.9916
Gaussian noise (0.001 density)	a. 0.7345
	b. 0.7606
	c. 0.7495
Sharpening	0.8811
Cropping	0.9481
Rotation 90^0	1.0
Rotation 10^0	0.8577
Image resize (50%)	0.9915
Gaussian filter (3×3)	1.0
Median filter (3×3)	0.9872

Table 2: Comparison between proposed method and Ramanjaneyulu*et al.* [12]

Attack type	**Ramanjaeyulu *et al.* [12]**	**Proposed Method**
Salt & Pepper noise (0.001 density)	0.9263	a. 1.0
		b. 1.0
		c. 0.9916
Gaussian noise (0.001 density)	0.3922	a. 0.7345
		b. 0.7606
		c. 0.7495
Sharpening	0.6987	0.8811
Cropping	0.4192	0.9481
Rotation 90^0	NA	1.0
Rotation 10^0	0.5695	0.8577
Image resize(50%)	0.6700	0.9915
Gaussian filter (3×3)	0.9069	1.0
Median filter (3×3)	0.8130	0.9872

Table 3: Comparison between proposed method and Lin *et al.*[17], P. V.Powar*et al.*[16]

Attack type	**P. V. Powar*et al.*[16]**	**Lin *et al.* [17]**	**Proposed Method**
Sharpening	NA	0.38	0.8811
Cropping	NA	0.61	0.9481
Rotation $.25^0$	NA	0.417	0.46
Rotation 10^0	0.607	NA	0.8577
Image resize	0.6508	NA	0.9915
Gaussian filter	NA	0.70	1.0
Median filter (3×3)	NA	0.35	0.9872
Median filter (4×4)	NA	0.26	0.7770

Table 2shows comparison results between Ramanjaneyulu*et al*. [12] and the proposed method.Table 3 shows comparison between the proposed framework and Lin *et al.*[17] and P. V. Powar*et al.*[16].

5. CONCLUSION

In this paper, a video watermarking technique based on DWT and FFT has been proposed. To increase the robustness watermark is embedded in LL2 sub-band after FFT transformation. And to ensure imperceptibility blocks with high entropies are selected to embed watermark from LL2 sub-band. Experimental results show that the proposed method compared with other methodis superior in terms of robustness against attacks like noise, rotation, cropping, sharpening etc. Value of the constant during the embedding process must be selected carefully in order to achieve imperceptibility.

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