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A Robust Video Watermarking Technique using DWT, DCT, and FFT

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***Abstract**—Proposed technique is based on dwt, dct, fft, and svd. First video is converted into frames. Apply DWT on each frame that will convert it into four sub-band frequency ranges as LL, LH, HL, and HH. Apply again DWT on LL sub-band then it will divide as LL1, LH1, HL1, and HH1 sub band of LL band. After applying DWT at 2-level, apply SVD in LL1 Sub-band, DCT in LH1 and FFT in HH1 sub-band of LL band. Same process will be applied on watermark symbol/image. Embed both host frame and watermark image with some scaling factor 'α'. For watermarked video arrange all the decomposed matrices using inverse technique. Watermarked video will be generated. To proof of ownership watermarking extraction process would be follow. And for proofing robustness and security level of this watermarked technique watermarked video will be compared with original video. And NCC, PSNR, BER value would be calculated.*

***Keywords**— dwt, dct, fft, svd, psnr, ncc, ber*

I. INTRODUCTION

Internet has become indispensible and thus the security and the privacy issue have come to the fore of the computing fraternity. These issues need to be addressed with utmost urgency and highest level of dedication.

Watermarking addresses the privacy and security issues. Watermarking has helped not just in security but also in resolving numerous copyright and privacy issues, which became one of the most contentious issues while the expansion of internet. This proposal explores the state of art introduces a novel technique to tackle the elephant in the room.

Watermarking techniques can be segregated on the basis of domain based, document based, Perception based and application based.

Domain of watermarking technique is divided in to two parts such as on the basis of spatial domain and other is on the basis of frequency domain.

In spatial domain watermarking, watermark is embedded by modifying the pixels value of the host image/ video directly. The main advantages of pixel based methods are that they are conceptually simple and have very low computational complexities and therefore are widely used in video watermarking where real-time performance is a primary concern. However, they also exhibit some major limitations. The need for absolute spatial synchronization leads to high susceptibility to de-synchronization attacks; lack of consideration of the temporal axis results in vulnerability to video processing and multiple frame collusion; and watermark optimization is difficult using only spatial analysis techniques.

In frequency domain, the watermark is embedded for the robustness of the watermarking mechanism. There are three main methods of data transmission in frequency domain. as DCT DFT and DWT. The main strength offered by transforming domain techniques is that they can take advantage of special properties of alternate domains to address the limitations of pixel-based methods or to support additional features. Generally, transform domain methods require higher computational time. In transform domain technique, the watermark is embedded distributive in overall domain of an original data. Host video is first converted into frequency domain by transformation techniques. The transformed domain coefficients are then altered to store the watermark information. The inverse transform is finally applied in order to obtain the watermarked video.

On the basis of document watermarking can be apply on Image, Text, Audio and Video. According to the human perception watermarking is divided in to two parts visible watermark media and invisible watermark media. Invisible watermark is further are of two types robust watermarking and fragile watermarking.

For effective watermarking the watermarking techniques need to be imperceptible (watermark should not degrade the quality of multimedia), robust (after applying attacks quality of multimedia should not be degrade), and secure from various attacks.

In Most of the watermarking techniques, the watermark is embedded into the frequency domain instead of the spatial domain for the robustness of the watermarking mechanism. Discrete Cosine Transformation (DCT), Discrete Fourier Transformation (DFT) and Discrete Wavelet Transformation (DWT) are the three main methods of data transformation in this domain. The main strength offered by transforming domain techniques is that they can take advantage of special properties of alternate domains to address the limitations of pixel-based methods or to support additional features.

Generally, transform domain methods require higher computational time. In transform domain technique, the watermark is embedded distributive in overall domain of an original data. Here, the host video is first converted into frequency domain by transformation techniques. The transformed domain coefficients are then altered to store the watermark information. The inverse transform is finally applied in order to obtain the watermarked video.

II. PAGE LAYOUT

An extensive literature review has been carried out to find the gaps in the existing works and to place the proposed work in perspective. The following table (Table 1) shows the summary of the work carried out so far.

Table I: Literature Review

S. No.	Technique proposed	Special Note	Reference No.
1.	Watermark embedding and extraction schemeIs proposed by applying 3-level DWT on selected RGB frame with secret key	Proposed work demonstrated by two videos and by two different logo images and show how watermark is detected or not detected	[5]
2.	For Embedding scene changing detection is performed and singular values of a binary watermark are embedded in LL3 Sub-band with some coefficients in video frames	To test the robustness of the video PSNR Value and Bit Error rate is calculated after applying the attacks	[6]
3.	2D-DCT/DWT techniques are applied for watermark embedding on video frames And after embedding process watermarking extraction is performed and PSNR value is calculated	Verified using MATLAB and PSNR is calculated for both technique DWT and DCT which shows DWT is better than DCT, Various attacks are also applied	[7]
4.	SVD watermarking is implemented. And also DWT based video watermarking scheme with scramble watermark symbol is used for improving the robustness	Imperceptibility, robustness and data payload is verified for both the algorithm, SVD shows better robustness and DWT shows higher data payload	[8]
5.	DWT is applied on each video frame. Maximum entropy blocks are selected and transformed using PCA. QIM is used to quantize each PCA blocks. Watermark is embedded in selective quantized value.	Robustness of video is checked by applying various attacks in both regular videos and in medical videos	[9]
6.	Adaptive frame selection technique is used using swarm optimization SD-BPSO to achieve maximum PSNR. And also generate a unique key which is used to extract the watermark	PSNR is calculated for validating integrity of the video. Various attacks are applied for robustness and BER is used for retaining the efficiency of the system.	[10]
7.	DWT is applied using two resolution levels on video frames. HH, LH and HL are SVD transformed and watermark is embedded in them	Verification of this technique is done by applying various attacks on watermarked video which shows better robustness as compare to only dwt based technique	[11]
8.	Watermark is embedded with QR(Quick Response) Code technique. QR code is watermarked code which is watermark by DWT-SVD Techniques, DWT is applied on SVD cover image or QR code Image	Performance of this technique is evaluated on MATLAB R2010a. A video sequence of size 512x512 is taken, video sequence is shown as IBBPBBPBBPBB and two GOP for watermarking are selected	[12]
9.	In This Neural Network model is used to generate and detect the watermark in images. Model is Designed for training process of the watermark pattern in the carrier image	Robustness is compared by applying various attacks and compared Correlation and PSNR values with other techniques.	[13]
10.	Video is converted in to frames the 3 Level DWT is applied on each frame, higher subband coefficients are selected for embedding the watermark image	For Robustness Verification of watermarked video various attacks are applied and threshold, correlation value is calculated with different scaling factor.	[14]

III. PROPOSED WORK

The proposed technique is a combined algorithm of four different techniques, discrete wavelet transform, discrete cosine transform, fast fourier transform and singular value decomposition. Using this technique effectiveness of watermarking for imperceptibility and robustness will be verified by applying various signal processing and geometric attacks. After applying all the attacks, performance of watermarked video frames will be evaluated by calculating MSE (Mean square error), BER(bit error rate), PSNR(peak signal to noise ratio), and NCC(normalized cross correlation) value.

A. Embedding Process

For watermark embedding process proposing a following Algorithm:

Step 1: In first step we convert the host video into number of frames as image database in jpeg format 'f'

Step 2: Convert all the frames from RGB to Gray.

As m1=rgb2gray(f)

Step 3: Resize the frames 'm2' as [256 256]

Step 4: Apply DWT on the host frame m2 called first level DWT.

Step 5: Again apply DWT for second level DWT on LL Band of size [64 64]

Step 6: Now Apply SVD on LL1 band of size [32 32]

This singular value decomposition decompose LL1 band into three matrices as U x S x V'Where U is an orthogonal matrix, S is a diagonal matrix and V' is a transpose of an orthogonal matrix.

Step 7: Apply FFT on HH1 Band of size [32 32] as FFTHH1

Step 8: Apply DCT on LH1 Band of size [32 32] as DCTLH1

For watermark image repeat all the steps from 1o 8

Step 9: For Embedding watermark image into host frame of the video, embed the coefficients matrices with some scaling factor 'α' as

Wimage1=SL+ α * SL_L1

Wimagw2=FFTHH1+ α * FFTH_H1

Wimage3= DCTLH1+ α * DCTLH_H1

For Watermarked Video

Arrange all the decomposed matrices after embedding

Let us take inverse of SVD as

ALL1= UL* Wimage1* VL'

Take inverse of FFT as

Wimage_level1=ifft2(Wimage2, 32, 32)

Take inverse of DCT as

Wimage_level2=idct2(Wimage3, 32,32)

Take inverse discrete wavelet transform for first reverse level

AWW1=idwt2(ALL1, LH1, HL1, HH1)

Now for second level IDWT

AWW2=idwt2(AWW1, LH, HL, HH)

This AWW2 will be the watermarked video.

Watermarked video will be generated

B. Watermark Extraction Process:

For watermark extraction process we will take watermark embedded video or frame AWW2, from which we will extract the watermark image or symbol in proof of ownership.

Step 1: Take watermarked video AWW2 and apply first level DWT on it. Which decompose it into four different sub band.

Step 2: Select LL sub-band from first level DWT and apply second level DWT which further decompose it into four sub-bands.

Step 3: Extracted watermark image= (Watermarked- Original)*1/α

WM1= (SX- SL)* 1/α

WM2=(FFTX-FFTHH1) * 1/α

WM3=(DCTX-DCTLH1)* 1/α

Where α is a scaling factor

Step 4: Take inverse of SVD, IDCT, IFFT, IDWT to rebuild the watermark.

finalxtract1=UL_L1 * WM1 * VL_L1

finalxtract2=ifft2(WM2, 32,32)

finalxtract3=idct2(WM3, 32,32)

Step 5: Apply inverse DWT at first level

finalxtract4=idwt2(finalxtract1, LH1, HL1, HH1)

Step 6: Apply inverse DWT at second level

finalxtract5=idwt2(finalxtract4, L_H, H_L, H_H)

Finalxtract5 is the extracted watermark image

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IV. RESULTS

Robustness is evaluated by performing various signal processing attacks on the watermarked video and evaluating the similarity of the extracted message to the original one.

The imperceptibility of watermark is tested through comparing the watermarked media with the original media.

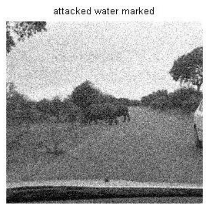
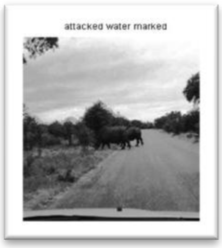
PSNR Value decides the quality measurement between the original media and a compressed media. Higher the value of the PSNR, better the quality of the compressed and the original or reconstructed media.

Mean Square Error (MSE) are used to compare compression quality. The summary of the results has been shown in Table II. In the table the proposed technique and the technique implemented previously [4].

Table II: Comparison with the previous technique

S. No.	Applied Attacks	Maximum PSNR Value Using proposed technique	PSNR using DWT-SVD [4]	Maximum NCC Value using proposed technique	NCC DWT-SVD [4]
1.	Watermarked video without Attack	81.6893	75.2323	0.8400	0.8446
2.	Gaussian noise attack	81.6893	59.9781	0.8400	0.8516
3.	Median Filtering Attack	81.6892	59.9883	0.8400	0.8458
4.	Frame Rotation	81.6893	59.9781	0.8458	0.8511
5.	Histogram Equalization	81.7824	59.9781	0.8595	0.8595
6.	Contrast Adjustment	81.6893	59.9781	0.8400	0.8394
7.	Sharpness attack	81.6893	59.9781	0.8400	0.8535

Table IIII: Depiction of result obtained from the implemented Algorithm.

S. No.	Watermark Attacks	Original watermark	Extracted Watermark	Watermarked Video frame After attack	PSNR	NCC
1.	Gaussian Attack				81.6893	0.8400
2.	Median Filtering				81.6893	0.8400
3.	Frame Rotation				81.6892	0.8400
4.	Histogram Equalization				81.6893	0.8400
5.	Contrast Adjustment				81.7824	0.8400

6.	Sharpness				81.6893	0.8400

V. CONCLUSION

Future scope of watermarking in video is very wide. Video watermarking is used to prevent unauthorized use of video files. And it is also used to avoid video piracy in broadcast video monitoring. Video sequencing is a collection of consecutive and equally time spaced still images. Apparently any image watermarking technique can be extended to watermark videos, but in reality video watermarking techniques needs to meet other challenges. Watermarked video sequences are very much susceptible to pirate attacks such as frame averaging, frame swapping, statistical analysis, digital-analog (AD/DA) conversion and lossy compressions. Our proposed technique is much better with other video watermarking technique.

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