Digital Watermarking Techniques using DCT and Correlation based Schemes applied on Video Frames

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Abstract— Research in information hiding has grown explosively. However, many questions still exist concerning the potential of the technology and its role in establishing and upholding intellectual property rights in the digital age. This work, provides an overview of information hiding, outlining its main disciplines (covert channels, steganography [1], digital watermarking, and anonymity), and some applications current driving interest. The focus is on the current status of and prospects for digital watermarking [2], devoting special attention to a taxonomy based on insertion domain, applicability, and types of existing algorithms. In this paper, a method is presented, to apply existing watermarking embedding and recovering techniques applied on extracted video frames, to cater the digital watermarking needs of the world by concentrating on embedding the watermarks in the R-G-B planes of colour images. For intellectual property right protection of multimedia images, the colour image is watermarked three times by embedding the same watermark in each plane of multimedia image. Multimedia images are divided into R-G-B colour planes and watermarks are inserted into the individual colour planes. One or more watermarks can be inserted into one or more of the colour planes. The authentication process consists of retrieving the watermarks from all the three colour planes and a final watermark is constructed from the intersection of all the retrieved watermarks. The proposed work has been implemented in both spatial domain and transform domain. For spatial domain, threshold-based correlation watermarking scheme is used whereas, for transform domain DCT based watermarking is done.

Keywords: Video Watermarking, Frames, Digital Watermark, DCT, Correlation

I. INTRODUCTION

Issues of intellectual property right and protection abound in this era of persuasive digital data. Digital watermarking gives the growing concerns of theft and tampering through the use of advanced signal processing strategies[4] to embed copyright and authentication information within multimedia content[5]. Well–established organizations are actively pursuing research into digital watermarking and are calling for proposals to incorporate research these methods in current multimedia standards [6],[7],[8]. Because this research is in its infancy many questions still exist concerning the potential of the technology and its role in establishing and upholding intellectual property rights [9] in the digital age. This paper examines digital watermarking from theoretical and applications-oriented aspects. Our target is to enhance the technology, calculate its appropriateness for certain problems, and widen its usefulness to multimedia intellectual property management.

II. RELATED WORK

In this paper, a method is presented to cater the digital watermarking needs of the world by concentrating on embedding the watermarks in the R-G-B planes of colour images. For intellectual property right protection of multimedia images, the colour image is watermarked three times by embedding the same watermark in each plane of multimedia image. Multimedia images are divided into R-G-B planes and watermarks are inserted into the individual colour planes. One or more watermarks can be inserted into one or more of the colour planes. The authentication process consists of retrieving the watermarks from all the three colour planes and a final watermark is constructed from the intersection of all the retrieved watermarks.

The work [7] has been implemented in transform domain. For transform domain DCT based watermarking [3] is done. The algorithms used to implement this scheme have been described below.

A. DCT based watermarking [13]-[17]:

The DCT permits an image to be broken up into different frequency bands, making it much easier to embed watermarking information into the middle frequency of the image.

The DCT is similar to DFT (discrete Fourier transform)[6]: it transform a signal or image from the spatial domain to the frequency domain.

1) DCT encoding:

The general equation for DCT transform is given by:

$$C(u,v) = \alpha(u)\alpha(v)\sum_{x=0}^{N-1}\sum_{y=0}^{N-1} f(x,y)\cos\frac{\pi u(2x+1)}{2N}\cos\frac{\pi v(2y+1)}{2N} \quad (2.1)$$

where u, v = 0,1,2….N-1 and the corresponding inverse 2D transform is given by:

$$C(x,y) = \sum_{x=0}^{N-1}\sum_{y=0}^{N-1} C(u,v)\alpha(u)\alpha(v)\cos\frac{\pi u(2x+1)}{2N}\cos\frac{\pi v(2y+1)}{2N} \quad (2.2)$$

where u, v = 0.1.2…, N-1

The basic operation of DCT is given by:

- The input image is N by M.
- F (x, y) is the intensity of the pixel in row x and column y.
- C (u, v) is the DCT coefficient in row u1 and column u2 of the DCT matrix.
- For most images, maximum of the signal energy lies at lower frequencies; these appear in the upper left corner of the DCT.
- Compression is achieved since the lower right values represent higher frequencies and are often small enough to be neglected with little visible distortion.

- The input is an N x M matrix (image) and the output is the DCT matrix of same dimension.

2) Computing the 2D DCT

The 2D DCT is computed by using the direct matlab function "dct2".A pseudo code is as follows:

dct_image = dct2 (input_image);

a) Comparison of mid-band DCT coefficients:

The most basic of the watermarking techniques is based on simple comparison of mid-band coefficients [7] of the DCT image.

In this method we transform the watermark into a straight vector having elements 1 or 0. Now the image is broken into blocks and then each one is processed to include one element of the watermark in it. For embedding we take two pixel locations in the mid-band of the DCT. These positions remain constant during the entire embedding process. (like (5, 2) and (4, 3) etc.). Now every time the message bit is 0 we make one of them (say (5, 2)) to be greater than the other (4, 3) and vice versa. To improve robustness, we increase the difference between these pixel values to 'k'. The higher the value of 'k', better the robustness of the watermark. Since all these changes happen in the mid band DCT, hence they are difficult to find visually. But increasing the value of k might cause some sort of patterns to appear in the images.
The algorithm of method-1 is given below:

To embed the watermark:

- Process the image in blocks.
- For each block
- Transform block using DCT.
- if message bit is 0.
- If dct_block (5,2) < (4,3) .
- Swap them.
- Else
- If (5,2) > (4,3)
- Swap them.
- If (5,2) - (4,3) < k
- (5,2) = (5,2) + k/2;
- (4,3) = (4,3) – k/2;
- Else
- (5,2) = (5,2) - k/2;
- (4,3) = (4,3) + k/2;
- Move to next block.

For recovering the watermark , we again break the watermark image into blocks and then process each block to find out whether the corresponding message bit is '0' or '1'. To determine this we check whether (5, 2) is greater than (4, 3), if it is then we assign the corresponding element of message as 1 and vice versa.
To recover the watermark:

- Process the image in blocks.
- For each block
- Transform block using DCT.
- If (5,2) > (4,3)
- Message = 1
- Else
- Message=0;
- Process next block.

B. Correlation based DCT watermarking [18]-[22]:

Another possible technique for transform domain watermarking is to embed a PN sequence W into middle frequencies of the DCT block. In this method, two different PN sequences that are highly uncorrelated are produced and embedded into the image. For this, first break the image into different blocks and then process each block. The block size is chosen such that the entire message/watermark can be written into it. Since, each block of the image can only store one bit of the watermark. After obtaining the blocks their DCT is computed. Now if the message bit is zero then embed the PN sequence (pn_sequence_0) to indicate the presence of bit '0' else insert the other PN sequence (pn_sequence_1). To improve the detection process it must be made sure that the PN sequences that are generated must be highly uncorrelated. Each image block is processed in exactly the same manner as mentioned above. The algorithm for the above method is given below:

1) To embed:

- Generate two "PN" sequences for 1 and 0.
- Find two highly uncorrelated sequences by generating two random PN sequences until the correlation between them is above a certain threshold.
- For each image block
- Transform the block using DCT.
- If message_bit is 0
- Embed pn_sequence_0 to the image block.
- Else
- Embed pn_sequence_1 to the image block.
- Take the inverse DCT
- Move to next block.

For watermark retrieval, the correlation property of PN sequences is used. First break the image into blocks and then take the DCT of each block. After that, for each block a vector is generated that contains the entire mid band frequencies of the concerned block. Now take the correlation of this vector with both the PN sequences and assign the message bit a '1' if the correlation of the vector with the pn_sequence_1 is higher than that with pn_sequence_0.

2) To recover:

- Generate two "PN" sequences for 1 and 0.
- Find two highly uncorrelated sequences
- Process the image in blocks.
- For each block
- Transform block using DCT.
- Extract the mid-band coefficients.
- Calculate the correlation of mid-band frequencies with both the sequences.
- If correlation (mid-band, pn_sequence_0)> correlation (mid-band, pn_sequence_1)
- Message=0;
- Else
- Message =1;
- Process next block.

III. WORK

A. Proposed Work:

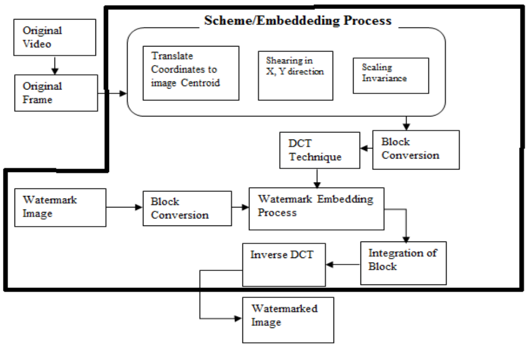


Fig. 1: Watermark Embedding Process to Video frames

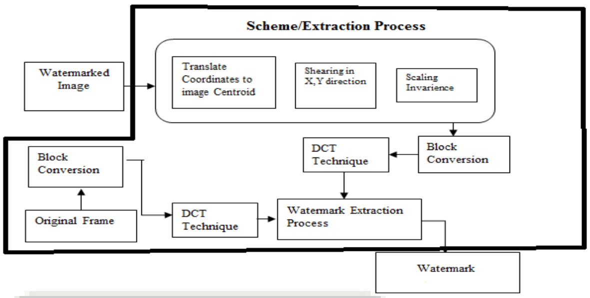
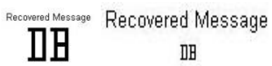


Fig. 2: Watermark Extraction Process to Video Frames

B. Video Frame Used:

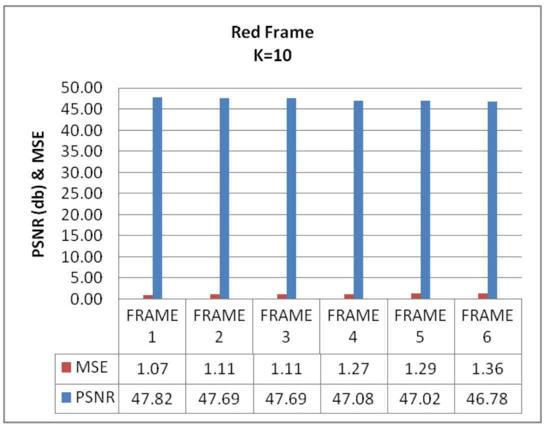
C. Applied Watermark:

D. Recovered Watermarks:



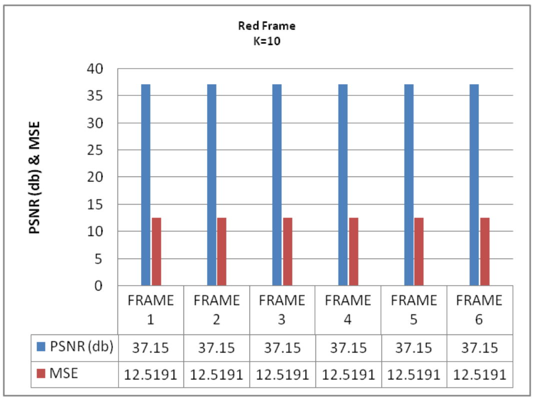
Method-1 Method-2

IV. RESULTS



	FRAME 1	FRAME 2	FRAME 3	FRAME 4	FRAME 5	FRAME 6
MSE	1.07	1.11	1.11	1.27	1.29	1.36
PSNR	47.82	47.69	47.69	47.08	47.02	46.78

Graph 1.1(a): PSNR & MSE calculation in Performance analysis of watermarking techniques for Mid Band Comparison.

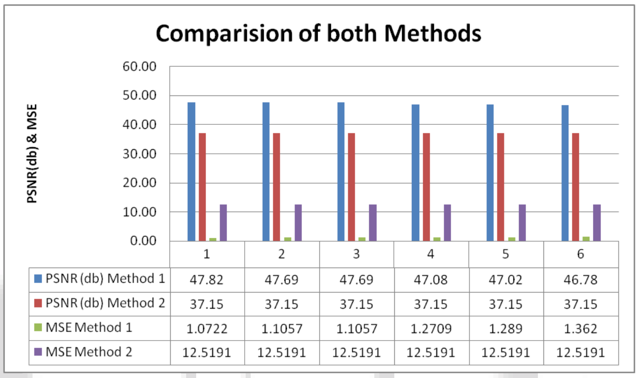


	FRAME 1	FRAME 2	FRAME 3	FRAME 4	FRAME 5	FRAME 6
PSNR (db)	37.15	37.15	37.15	37.15	37.15	37.15
MSE	12.5191	12.5191	12.5191	12.5191	12.5191	12.5191

Graph 1.1(b): PSNR & MSE calculation in Performance analysis of watermarking techniques for Correlation based DCT.

V. COMPARISON

The Graph showing below the comparison of both the methods used in the paper.



	1	2	3	4	5	6
PSNR (db) Method 1	47.82	47.69	47.69	47.08	47.02	46.78
PSNR (db) Method 2	37.15	37.15	37.15	37.15	37.15	37.15
MSE Method 1	1.0722	1.1057	1.1057	1.2709	1.289	1.362
MSE Method 2	12.5191	12.5191	12.5191	12.5191	12.5191	12.5191

Graph 1.1(c): Comparison of both the methods for PSNR & MSE calculation.

VI. CONCLUSION

The key conclusion of this study is that these methods can be easily applied to color images and these color watermarked images thus obtained have been shown to be much more robust to the normal watermark removal as well as special removal. (i.e. watermark retrieval in case of attacks like noise addition, compression etc.). Moreover the proposed color image watermarking can be used to improve the quality of the retrieved watermark. The improved quality can be attributed to the fact, that the noise which usually crept in the final watermark during the retrieval process is mostly random and thus the retrieval of the same watermark from the three color planes (R, G, B) of the color image might contain some random noise but the noise won't be there at the same place in all the three of the planes. Hence when the intersection of all the three watermarks was taken, the final watermark retrieved appears to be less noisy.

The final watermarks thus obtained by proposed work are visually more similar to the original watermark than the ones obtained by these methods for grayscale images. Moreover the presence of noise also hinders the performance of detection software's that might be employed for retrieving as well as matching these watermarks with their original images and hence their performance is reduced significantly. This study will significantly improve the matching power of such detection software's.

Another observation of this work is that transform domains watermarking techniques are typically better candidates for digital watermarking of images than spatial domain techniques, for reasons of robustness as well as visual impact. Embedding the watermark in the transform domain proved to be highly resistant to JPEG compression as well as significant amounts of random noise, by predicting which coefficients would be modified by the subsequent transform and quantization, DCT watermarking schemes were able to produce a watermarking technique with high robustness, good capacity, and low visual impact.

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