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Watermarking Digital Images: A Hybrid Approach

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Abstract—The increasing demand for protection, privacy and security of digital content makes it important to develop techniques that are more robust and secure. watermarking is identified as a major technique to obtain copyright protection since high degree of compression is required along with preserving critical image information, so many transformation techniques are used commonly such as DCT,DWT,DFT.DCT having high compaction property and requiring less computational resources while as DWT is multi resolution transformation. In this paper results of different performance criteria in existing techniques of DCT and DWT are calculated and a hybrid DCT-DWT algorithm is proposed.The algorithm performs haar DWT on grayscale cover image and HH and watermark is inserted.simulation results show hybrid technique has better PSNR,MSE,SNR in comparison to standalone techniques. Advantages of the two said techniques are exploited, thus making for each othersdisadvantages.Thus resulting in high robustness, higher image quality against common signal processing attacks.

Keywords: DCT, DWT, PSNR, MSE, SNR.

I. INTRODUCTION

Data Hiding[1]techniques have evolved as an exciting and important research field which encompasses steganography[2]and cryptography andwatermarking[3].Watermarking is a type of steganography but complements cryptography.Watermarking is considered as an interdisciplinary study that draws attention from multiple fields. some applications of watermarking are fingerprinting, indexing, copyright protection& owner identification, broadcast monitoring, copy protection, data authentication, data hiding. some requirements of watermarking are cheap and easy implementation, tamper resistant, transparency and robustness.Watermarkis secret data which is embedded into a digital signal without degrading the image quality. Digital signal into which watermark is to be embedded is called as host or cover signal which can betext , image , audio ,video.Digital watermarking[4, 5] is one of the most popular techniques[6] being used for digital data authentication and copyright protection. watermarking techniques[7]-[8, 9][10]can be classified in different ways like availability of original data(blind and non blind),privacy(asymmetric and symmetric), robustness[11](robust, fragile, semi fragile) , watermark type(noise, image) , host data (image, audio , video) ,domain(spatial, frequency). Spatial domain includes LSB , predictive, correlation techniques and frequency domain includes DCT, DWT , DFT. Spatial-domain watermarking modifies pixel values directly on the spatial domain of an image. In general, spatial-domain watermarking schemes are simple and do not need the original image to extract the watermark.LSB coding is one of the earliest methods. It can be applied to any form of watermarking. In this method the LSB[12] of the carrier signal is substituted with the watermark in a sequence which acts as a key and is used in retrieving the watermark back .In Predictive coding scheme the correlation between adjacent pixels are exploited. A set of pixels where the watermark has to be embedded is chosen and alternate pixels are replaced by the difference between the adjacent pixels and can be further improved by adding a constant to all the differences. A cipher key is created which enables the retrieval of the embedded watermark at the receiver. This is much more robust as compared to LSB coding.In patchwork watermarking,one feature or an operation is chosen and it is applied to two subsets (which are obtained by dividing the image) in the opposite direction that is if for example one subset is increased by a factor m, the other subset will be decreased by the same amount. We here focus on Frequency domain techniques wherethe secret data are hidden in the lower or middle frequency portions of the protected image, because the higher frequency portion is more likely to be suppressed by compression. But how to select the best frequency portions of the image for watermark is another important and difficult topic.Two basics reasons why we use transformation is , first we get coefficients which are de-correlated and secondTransform coefficients have energy compaction capability that means bulk of energy contained by signal are carried by certain few coefficients.Therefore truncating those coefficients which do not contain much significant information. These techniques are being implemented on an efficient and high end data sources [37-50]which includes a simple database to high end database warehouse for information security.

In this paper a hybrid DCT-DWT algorithm is proposed. The algorithm performs hear DWT on grayscale cover image and HH band is selected for watermark insertion. Next selected HH band is divided into blocks of 8*8 and DCT is applied to each 8*8 blocks and watermark bits are inserted into mid frequency coefficients. The paper is organised in the following sections. In section 2 we describe Existing approaches. In section 3 we define quality evaluation measures. Section 4 contains literaturesurvey. In section 5 we define the problem. Section 6 contains proposed hybrid algorithm. In section 7 we have written all simulation results. Section 8 contains observations from the results. Finally we conclude with section 9 giving the overall conclusion.

II. EXISTING APPROACH'S

A. Discrete cosine transform (DCT)

In digital signal processing one of the common linearfrequency transformation is DCT.For enhancing characteristics like robustness and imperceptibility DCT separates image into three main regions based on frequency, high, middle and low frequency. Modification in low frequency is perceptible because much of signal energy lies in low frequency region while as modification in high frequency creates local distortions. Middle frequency is best used for preserving image quality. In general DCT converts data in spatial domain to a sum of sine and cosine waveforms with different amplitudes in the frequency domain[13],[14]. One dimension and two dimensional discrete cosine transformation(1D-DCT& 2D-DCT) are used, we define only 2D as we are only using images:

2D-DCT:

$$c(u,v) = \alpha(u)\alpha(v)\sum_{x=0}^{N-1}\sum_{y=0}^{N-1} f(x,y)\ \cos\left[\frac{\pi(2x+1)u}{2N}\right]\cos\left[\frac{\pi(2y+1)}{2N}\right] \quad ly$$

Where, $\alpha(u) = \left[\sqrt{\frac{1}{N}}\right]$ For u = 0

$\alpha(u) = \left[\sqrt{\frac{2}{N}}\right]$ For u !=1

B. Discrete Wavelet Transform(DWT)

Similar to human visual system DWT[15] has good spatial localisation and multiresolution characteristics[16],[17],[18]. DWT divides image into four non-overlapping multi-resolution sub bands having highest magnitude of DWT coefficients in the lowest region(LL) at each level of decomposition and lowest of the rest three bands (HH, LH ,HL).Embedding at lowest frequency(LL) has high robustness but degrades image significantly whereas embedding in high frequency(HH) has high imperceptivity but less robustness. Hence embedding in middle frequency (LH, HL) is better option for both robustness and perceptivity to remain preserved? Overall DWT is robust to low-pass and median filtering but not to geometric transformation. In the following figure 3-level decomposition in image using DWT is shown. At start the image is decomposed into four bands HH, HL, LH, and LL. Next low frequency band (LL) is divided into sub-level frequency bands HH2, HL2, LH2, and LL2. Further low-frequency band LL2 is divides into sub-sub-levels HH3, LH3, HL3, and LL3. In this way the original image is divided into n level wavelet transformation [19-21]

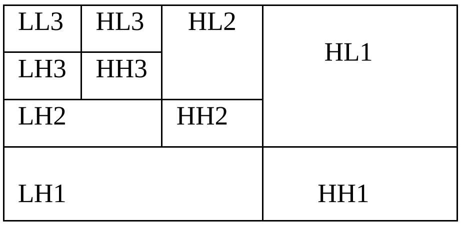


Fig 1 DWT ISTLevel Splitting

DWT has some advantages over DCT which makes it a better option of transformation than DCT .wavelet transformed image being multi resolution can be shown at multiple levels of resolution and can be sequentially processed from low resolution to high resolution. Further wavelet transform provides both frequency and spatial description for an image unlike DCT .DWT avoids blocking artefacts and has higher flexibility. In addition DWT transform is closely related to HVS and has high PSNR (measure of image quality) valve.

III. QUALITY MEASURES

A. The MSE (mean square error)

It is defined as average squared difference between a reference image and a distorted image.It is calculated by the formula given below X and Y are height and width respectively of the image.

$$MSE = \frac{1}{MN}\sum\sum(W_{IJ} - H_{IJ})^2$$

Where M,N is height and width in image, and Hij = Pixel value in host image, Wij = Pixel in watermarked image.

B. Signal to Noise ratio (SNR)

It measures the sensitivity of the imaging.It measures the signal strength relative to the background noise. It is calculated by the formula:

$$SNR_{db} = \log 10 \log_{10}(P_{signal} \div P_{noise})$$

C. The PSNR (peak signal to noise ratio)

The bigger the PSNR value is, the better the watermark conceals. It is used to determine the degradation in the embedded image with respect to the host image. Its unit is db. .It is calculated as:

$$PSNR = 10\log_{10}(L * \frac{L}{MSE})$$

WhereL is the peak signal value of the cover image which is equal to255 for 8 bit images.

IV. LITERATURE SURVEY

A survey of latest techniques that are employed in watermarking image's ,is done[8].This paper lists some advantages of DWT over DCT. It also lists some disadvantages of DWT such as Computational complexity.

A hybrid DCT-DWT scheme was applied under high compression ,to several images[22].Experimental results are compared with some existing algorithms and shows proposed algorithm is more robust and efficient.

Content based watermarking of 4 different types of watermark generation schemes for image authentication using hybrid DCT-DWT are presented[23].The algorithm embeds the watermark in, the HVS equivalent of the host image and changes it to RGB equivalent watermark image. Simulation results show that joint DCT-DWT hybrid technique with HSV is robust for compression, noise, and other attacks .Quality of watermarked image is better than existing techniques.

An algorithm combining DCT,DWT schemes and based on HVS is proposed[24].Further the algorithm applies discrete cosine transformation in high frequency band of image which has been already wavelet transformed. Experimental results show that image quality is preserved and the proposed algorithm is highly robust against different image processing attacks along with high capability of embedding signal and anti-attack.

A hybrid technique using DCT,DWT and hash function is put forward[25].Further two watermarks are embedded in the cover image ,one as robust watermark and other as fragile watermark. Hybrid DCT-DWT is used in embedding robust watermark in high frequency domain for copyright protection while as Hash function is used for embedding fragile watermark in spatial domain for authentication of ownership of image. Simulation results show transparency for multi-watermarking is preserved and resists strong geometrical attacks, jpgcompression, resizing attacks.

Joint DCT-DWT techniques are applied and are compared with standalone DCT,DWT techniques[26].Joint DCT-DWT is applied directly to the image as well as same technique is applied after dividing the cover image and watermark image into four. Simulation results show joint DCT-DWT is best technique among all having high PSNR and NC and DWT the second best .By diving the watermark and cover image into four doesnot give better results but makes this technique more resistant to attacks like noise.

To overcome the drawbacks of bothtechniques, ajoint DCT-DWT algorithm isproposed. Watermark is embedded in the special middle frequency coefficient sets of 3-levels DWT transformed of a host image, followed by computing 4*4 block-based DCT on the selected DWT coefficient sets. Increase in robustness and imperceptibility is achieved[27].

A joint DCT-DWT technique is applied on colour images[28].The performance is calculated by measuring PSNR and NC, and further these factors are compared with standalone DCT algorithm. Simulation results show that hybrid technique is imperceptible and robust against variety of attacks.

In addition other work done using hybrid DCT-DWT is [29]],[30, 31][32].

V. PROBLEM DEFINITION

There are three main characteristics of a watermarking scheme which must be obtained, robustness[3], imperceptibility, capacity. Both DCT and DWT obtain some of them but have some loopholes at the same time. Since DWT is preferred over DCT as discussed already yet has some disadvantages like computational cost of DWT is higher than DCT , longer compression time, lower quality than jpeg at lower compression rates, Use of larger DWT basis function causes blurring and ringing noise near edge region in image.There is no such ideal standalone technique which Performs well in all areas. Therefore to improve performance different techniques are joined together to work in best possible way to make up for each other's disadvantages. So problem statement is to implement a joint DCT_DWT scheme and compare the simulation results with standalone DCT and DWT to show that hybrid technique gives best results of robustness and imperceptibility.Further joint DCT-DWT removes blocking artefacts, false contouring and ringing effect.

VI. PROPOSED HYBRID TECHNIQUE

DCT-DWT used as a joint technique improves performance in terms of robustness and imperceptibility. It results in higher PSNR, thusresulting in good image quality.The algorithm performs haar DWT on grayscale cover image. Then we select HH band for watermark insertion.Next selected HH band is divided into blocks of 8*8 and DCT is applied to each 8*8 blocks and watermark bits are inserted into mid frequency coefficients by adjusting coefficients DCT(4,3) and DCT(5,2). The algorithm foe hybrid DCT_DWT is as:

1.Take cover image N×N and watermark image of size n×n as an input.

2.Apply haar DWT to cover image.

3.Select HH band and divide the image into 8×8 sized blocks.

4.Determine maximum watermark size based on cover image and block size by :

Max_watermark size = N×N/block_size.

5. Check that the watermark " is not too large"for cover image.

6.Pad the watermark out to the maximum watermark size with ones.

7.Transform block using DCT.

8.Embeds watermark bit=0 when DCT(5,2) is greater than or equal to DCT(4,3) and embeds watermark bit=1, when DCT(5,2) is less than DCT(4,3).

9. If watermark bit=0,then DCT(5,2) should be greater or equal to DCT(4,3) and if DCT(5,2) is less than DCT(4,3) then we need to swap them.

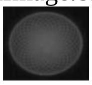
10. If watermark bit=1,then DCT(5,2) should be less than DCT(4,3) and if DCT(5,2) greater than DCT(4,3) then we need to swap them.

11.Adjust the two valuessuch that there difference is equal to k process which is known as minimum coefficient difference of DCT blocks.
12. Transform block back into spatial domain by IDCT which gives us watermarked image.
13. Apply inverse wavelet transform IDWT.

VII. SIMULATION RESULTS

The proposed algorithms DCT,DWT and Hybrid DCT-DWT is tested on different images named as Lena,Stars and Clock of different size (256×256),(240×240),(260×260).The watermark images used are named as wmlogo, logo, wmimage.The image are in bmp format. For evaluating performance of above mentioned techniques we use peak signal to noise ratio (PSNR), mean square error (MSE), and signal to noise ratio (SNR).
Comparison of different quality factors in different techniques using different cover images and watermark images: we calculate the performance evaluators PSNR and MSE of all techniques. The results show hybrid technique gives better image quality as the PSNR (above 30 is better) is high than other two. It is clear from the graph represented below in FIG 1 that PSNR of Hybrid DCT-DWT is higher than individual DCT and DWT.

Table 1 Comparison of Performance in all Techniques

Image	Watermark Image	Performance evaluation	DCT	DWT	DCT-DWT
Lena.bmp 	wmImage.bmp 	MSE	9.285	489	1.0645
		PSNR	37	21.97	48
		SNR	18.40	18.40	18.40
clock.bmp 	Mark.bmp 	MSE	13.2754	7.8722e+03	2.6069
		PSNR	36.9003	9.2038	43.9695
		SNR	20.2904	20.4766	20.4766
Stars.bmp 	Loogo.bmp 	MSE	8.4456	6.7515e+03	0.8230
		PSNR	38.8645	9.8708	48.9766
		SNR	19.5706	20.1545	19.5696

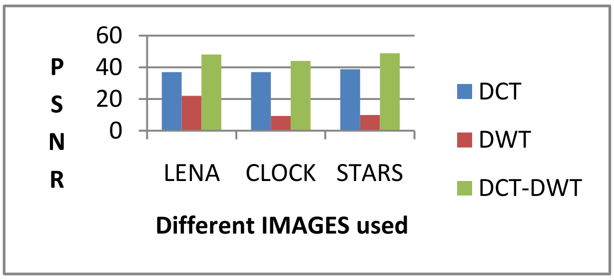


Fig 1 PSNR in Different Images using Different Techniques

Elapsed time is calculated as a difference between CPU time and starting time of the algorithm. Theoutput results of algorithms show that the mean computation time of hybrid DCT-DWT technique takes less time than the other two standalone techniques.

Table 2 Comparison of Elapsed Time

Elapsed time DCT	Elapsed time DWT	Elapsed Time Joint DCT-DWT
1.5756	2.4180	1.4040

Variance of performance evaluators with changing valve of K in hybrid DCT-DWT technique: Image used is clock.bmp and watermark used is mark.bmp. We change the value of K, as the value of K increases PSNR decreases and MSE increases. With increasing K, SNR also decreases.FIG.1 shows PSNR and MSE chart of clock cover image at different values of K. Higher values of PSNR means good quality of image.

Table 3 Change in Performance Evaluators with Increasing K

S-no	K	PSNR	MSE	SNR
1	10	43.6573	2.8012	20.2970
2	20	42.7345	3.4645	20.2965

3	30	41.4748	4.6302	20.2958
4	40	40.0448	6.4357	20.2947
5	50	38.7281	8.7150	20.2935

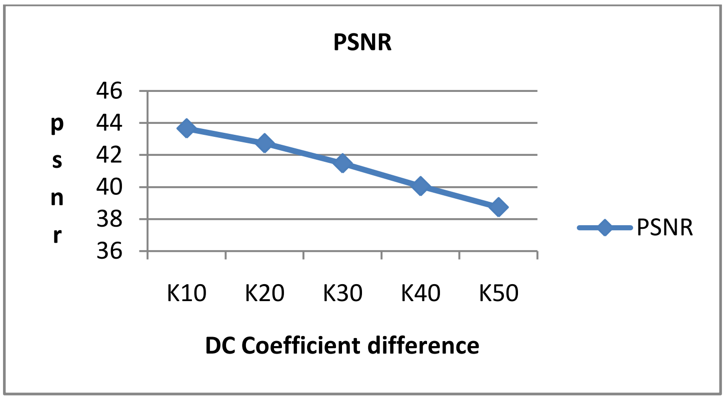


Fig 2 Variance of PSNR with DC Coefficient Difference

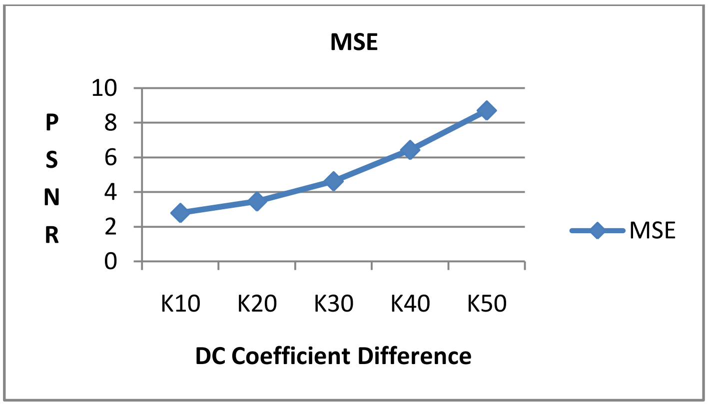


Fig3 Variance of MSE with DC Coefficients

Variance of PSNR after different attacks[33][34, 35]on images.we perform different types of attacks on watermarked image like adding different types of noise, rotating watermarked image at some angle, applying different types of filtering techniques [36], and observe the results carefully to prove that hybrid technique has more capacity to withstand attacks.

Table 4 Different Image Processing Attacks

SNO	Attacks	Performance evaluation	DCT	DWT	Hybrid DCT-DWT
1	Poisson noise	MSE	150.3009	5.5705e+03	141.9978
		PSNR	26.3612	10.7058	26.6080
2	Salt & pepper	MSE	103.8429	5.6911+03	17.3306
		PSNR	27.9670	10.6128	35.7427
3	speckle	MSE	98.4146	5.5708e+03	9.9237
		PSNR	28.2002	10.7058	38.1641
4	Gaussian noise	MSE	647.4101	5.6022e+03	641.5721
		PSNR	20.0190	10.6812	20.0583
5	Rotation	MSE	5.0254e+03	7.1461e+03	5.0778e+03
		PSNR	11.1191	9.6241	11.1257
6	Gaussian noise and rotation	MSE	5.5847e+03	7.0640e+03	5.5910e+03
		PSNR	10.6608	9.6743	10.6559
7	Gaussian filter [5 5]	MSE	941.6108	63309e+03	925.6984
		PSNR	18.3921	10.1708	18.4661
8	Average filter [3 3]	MSE	49.1053	6.2959e+03	940.6720
		PSNR	20.02195	10.1742	20.9645

9	Disk filter	MSE	643.5121	6.2719e+03	941.5379
		PSNR	20.0452	10.1908	20.6924
10	Laplacian filter	MSE	46.1187	6.2790e+03	638.5143
		PSNR	20.0125	10.1859	20.0891
11	Logarithmic filter	MSE	645.1480	6.2903e+03	640.3038
		PSNR	20.0220	10.1781	20.0669

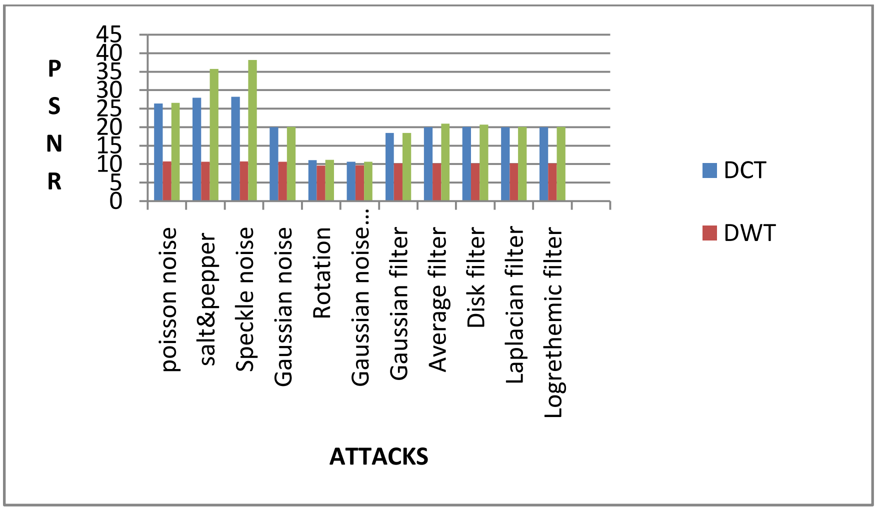


Fig 4 Comparison of PSNR with Different Attacks

VIII. OBSERVATION

Since it's clear from the above results that the hybrid technique gives better results than the standalone techniques. The quality estimation measures like PSNR, MSE, and SNR show better results for hybrid technique than DCT and DWT. After attacking the watermarking image by different kinds of noise, rotatingthe watermarked image and adding different filters, even the DCT Technique preserves image quality to a good extent by showing better values of PSNR but hybrid technique in addition to preserving image quality adds multi resolution characteristics and has an excellent spatial localization. Thus hybrid technique algorithm has better robustness and security.

IX. CONCLUSION

In this paper we use a frequency domain hybrid DCT-DWT digital image watermarking technique and it has better quality of image than existing techniques.Watermarking is done with embedding the watermark in middle frequency coefficient sets of DWT transformed host image,followed by computing 8×8 block based DCT sets on the selected DWT coefficients.Performance of hybrid technique as well as standalone techniques is measured by using PSNR, MSE, SNR, and are compared with each other. The results show higher PSNR values in hybrid technique than other indicating much better image quality. Also we change the value of K(DC Coefficient ofdifference),as the value of K increases PSNR decreases and MSE increases and with increasing K, SNR decreases. We then perform different attacks by adding noise and rotating image at different angles as well as adding different filters on the watermarked image. Experimental results show hybrid method is robust against variety of attacks like salt-pepper noise, Gaussian noise, speckle noise and filtering attacks like Median filter, Gaussian filter.

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