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Combined DWT-DCT Digital Watermarking Technique used for Cheque Truncation System (CTS) of Bank.

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ABSTRACT
A cheque truncation system (CTS) is used for the faster clearing of cheque. CTS of bank sends electronic cheque images to drawee branch for payment through the clearing house. It is normally believed that the system is safe and secure. However, the intruders may damage the data and can degrade the quality of cheque image or can duplicate cheque image. There is necessity of security and copyright protection. By using combined Discrete Wavelet Transform (DWT) and Discrete Cosine Transform (DCT). It is implemented imperceptibility of watermark which are supported for copyright protection and security for the cheque images.
Keywords - CTS, DWT, DCT, Digital Watermarking.

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I. INTRODUCTION

With the increasing use of Internet and effortless copying, tampering and distribution of digital data, copyright protection for multimedia data has become an important issue. Digital watermarking is a technique of embedding one digital information into another digital information without changing the content of original information. This method is emerged as a tool for protecting the multimedia data from copyright infringement. In this method an imperceptible signal ‘‘mark’’ is embedded into the host image, which uniquely identifies the ownership. After embedding the watermark, there should be no perceptual degradation. These watermarks should not be removable by unauthorized person and should be robust against intentional and unintentional attacks. Watermarking is also called as tamper-proofing or content verification which hides a secret and personal message to protect a products copyright. It mainly focuses to demonstrate its data integrity, secure, fast digital data encryption and decryption, content verification (authentication) of the received data by the recipient, robust and trustworthy marks indicating copyright and legal ownership.

The hiding process has to be such that the modifications of the media are imperceptible. For images this means that the modifications of the pixel values have to be invisible. A digital watermark is a message which is embedded into digital content (video, images or text) that can be detected or extracted later. Moreover, in image the actual bits representing the watermark must be scattered throughout the file in such a way that they cannot be identified and manipulated. Watermarking is the insertion of imperceptible and inseparable information into the host data for data security & integrity.

They are characterizing patterns, of varying visibility, added to the presentation media as a guarantee of authenticity, quality, ownership, and source. However, in digital watermarking, the message is supposed not to visible (or at least not interfering with the user experience of the content), but (only) electronic devices can retrieve the embedded message to identify the code. Another form of digital watermarking is known as steganography, in which a message is hidden in the content without typical citizens or the public authorities noticing its presence.

Only a limited number of recipients can retrieve and decode the hidden message. Unlike a traditional watermark on paper, which is generally visible to the eye, digital watermarks can be made invisible or inaudible. They can, however, be read by a computer with the proper decoding software. www.studymafia.image with the help of embedding procedure watermark is embedded and then get a watermarked image.

Commonly used frequency-domain transforms include the Discrete Wavelet Transform (DWT), the Discrete Cosine Transform (DCT) and Discrete Fourier Transform (DFT). However, DWT has been used in digital image watermarking more frequently due to its excellent spatial localization and multi-resolution characteristics, which are similar to the theoretical models of the human visual system [1]. Further performance improvements in DWT-based digital image watermarking algorithms could be obtained by combining DWT with DCT. The idea of applying two transforms is based on the fact that combined transforms could compensate for the drawbacks of each other, resulting in effective watermarking.

II. RELATED WORK

A Chiou-Ting Hsu et.al., [2] experimented the image processing operations, image cropping and the Joint Photographic Experts Group (JPEG) lossy compression. In this approach, watermark is embedded with visually recognizable patterns into the images by selectively modifying the middle frequency parts of the image. Several variations of the proposed method will be addressed. The experimental results show that the proposed technique successfully survives the above parameters. Subhashini et al.,[3] presented a paper on reversible watermarking technique for digital images. In this context, reversibility refers to the ability to restore the original image by the watermark detector. The technique is based on a transformation function that introduces 'gaps' in the image histogram. The 'gaps' are used to encode the watermark. Several experiments revealed that a relatively high embedding rate may be achieved. For a set of test images obtained embedding rates between 0.06 and 0.6 bits per pixel at PSNR levels of 45-50.

Elango [4] proposed project that provides high robustness, effectiveness and imperceptible to the watermarked image and achieves high PSNR value. In addition to this, it can also protect the content even after decryption is done. Image watermarking is a technique to authenticate the user files by embedding and hiding digital code behind an image. For clearing the cheque rapidly, CTS is used. The digital cheque images are transmitted through Internet. It is normally considered that the system is safe and secure. But in practical, the intruders may damage the quality of cheque image or duplicate the cheque image. In order to maintain security and copyright protection, image watermarking is a powerful technique for this purpose based on DWT & DES.

Mehdi et al.,[5] has explained an improved algorithm based on Discrete Wavelet Transform (DWT) and Discrete Cosine Transform Quantization Coefficients Decomposition (DCT-QCD) to detect such cloning forgery. Copy-move forgery is a specific type of image tampering where a part of the image is copied and pasted on another part generally to conceal unwanted portions of the image. Hence, the goal in detection of copy-move forgeries is to detect image areas that are same or extremely similar. The experimental results which show that the proposed scheme accurately detects such specific image manipulations as long as the copied region is not rotated or scaled and copied area pasted as far as possible in specific position from original portion.

Ashwani et al.,[6] proposed a new SVD based and DCT-DWT oriented watermarking scheme. It aims to achieve robustness with high perceptual transparency and low insertion ratio. The middle band DCT coefficients are chosen to achieve high robustness against JPEG compression. Robustness against other attacks is achieved by taking DWT of the DCT coefficients and the lowest frequency LL band of DWT is chosen for insertion. Insertion method in proposed technique uses SVD because slight variation of singular values does not change the visual perception of the image.

Ben Wang et.al.,[7] proposed an algorithm based on DWT, DCT and SVD. Experimental results show that this algorithm combines the advantages of these three transforms. It can satisfy the imperceptibility and robustness very well. Furthermore, the algorithm is robust to the common image process such as JPEG compression, noise, filtering, cutting, rotation, and contrast enhance. Applying the Arnold transform to the watermark improves the robustness greatly. Compared with the SVD and the DCT+SVD algorithms, the proposed algorithm has stronger robustness and faster speed in embedding and extracting.

Chatterji et.al., [8] presented a new scheme on wavelet-based logo-watermarking for copyright protection of digital image. Instead of using a noise type Gaussian sequence, a visually meaningful gray scale logo is used as watermark. Watermark embedding process is carried out by transforming both the image and logo in wavelet domain. To embed the watermark robustly and imperceptibly, watermark bits are added to the significant coefficients of each sub-band selected by considering the human visual system (HVS) characteristics. A scheme is developed for reliable extraction of watermark from distorted images. From the experimental results it can be observed that proposed method is robust to wide variety of attacks. Comparison with the existing methods shows the superiority of the proposed method.

Khellah et.al., [9] presented an approach on the dynamic estimation of large-scale stochastic image sequences, that emulates the Kalman filter, but with considerably reduced computational and storage requirements. However, the size of such images makes conventional dynamic estimation methods, for example, the Kalman and related filters, impractical. This approach is illustrated in the context of a 512 X 512 image sequence of ocean surface temperature. The static estimation step, the primary contribution here, uses a mixture of stationary models to accurately mimic the effect of a nonstationary prior, simplifying both computational complexity and modeling. The approach provides an efficient, stable, positive definite model which is consistent with the given correlation structure. Thus, this method may find application in modeling and single-frame estimation.

Yang Qianli et.al., [10] proposed a digital watermarking algorithm with gray image based on 2 dimensions discrete wavelet and cosine transform in order to protect digital media copyright efficiently. Image is transformed to discrete wavelet domain for three times and split the image into sub-blocks, which is lower in horizontal direction and high in vertical direction, and then transform every block into discrete cosine domain, the watermarking components, which is also transformed into discrete cosine domain, are embedded into cover image. Finally, the secret image is obtained by reverse transform of wavelet and cosine domain. The experimental results show that the watermarking is robust to the common signal processing techniques including JPEG compressing, noise, lowpass filtering and cutting.

Nidhi et.al., [11] implemented and proposed a performance analysis of two different watermarking schemes based on DCT-DWT-SVD. Both are non blind techniques. One is based on SVD of DCT coefficients using second level DWT decomposition and other is consider SVD of all DCT values of second level DWT composition of cover image. To check effectiveness of both techniques for Imperceptibility and robustness PSNR and NCC parameters are used.

Sarita et.al., [12] discussed about the Formulation, Process Flow Diagrams and algorithms of Principal Component Analysis (PCA), DCT (Discrete Cosine Transform) and DWT (Discrete Wavelet Transform) based image fusion techniques. The results are also presented in table & picture format for comparative analysis of above techniques. The PCA & DCT are conventional fusion techniques with many drawbacks, whereas DWT based techniques are more favorable as they provide better results for image fusion.

III. BACKGROUND

3.1. Watermarking procedure

There are two types of watermarking procedures. They are

3.2. Embedding procedure

With reference to Fig.1 for this process firstly 3 level DWT is applied on host image which decomposes the image into sub-images. The approximation looks just like the original.In the same manner 3 level DWT is also applied to the watermark image. For this haar wavelet is used. Then technique alpha blending is used to insert the watermark in the host image.

Alpha blending: Alpha blending of the watermarked image is given by equation (1).

WMI: k*(LL3) +q*(WM3) (1)

WM3 = low frequency approximation of Watermark, LL3 = low frequency approximation of the original image, WMI=Watermarked image, k and q-Scaling factors. After embedding the watermark image on cover image, Inverse DWT is applied to the watermarked image coefficient to generate the final secure watermarked image.

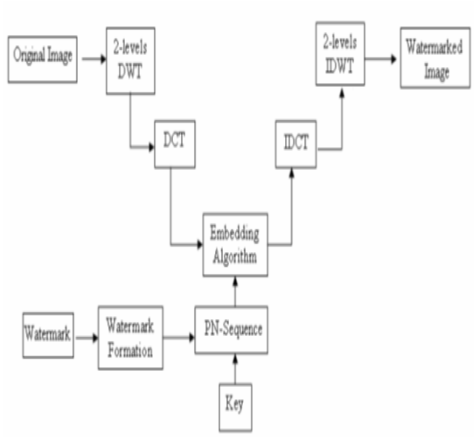

Figure.1 Combined DWT-DCT watermark embedding procedure.

3.3. Extraction Procedure

Similarly, with reference to Fig.2 for extraction procedure firstly 3 level DWT is applied to watermarked image and host image which decomposes the image into sub-bands. After this alpha blending is applied on low frequency components. Alpha blending of Recover watermark image is given by equation (2).

RW : (WMI - k*LL3) /q (2)

RW= Low frequency approximation of Recovered watermark, LL3=Low frequency approximation of the original image, and WMI= Low frequency approximation of watermarked image. After extraction process, Inverse DCT is applied to the watermark image coefficient to generate the final watermark extracted image.

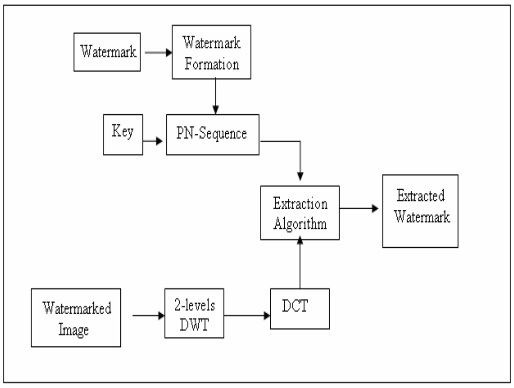

Figure.2 Combined DWT-DCT watermark extraction procedure.

3.4. Transforms

Transform domain embeds a message by modifying the transform coefficients of the cover message as opposed to the pixel values. There are a number of transforms that can be applied to digital images, but there are notably three most commonly used in image watermarking. They are;
Discrete Cosine Transform (DCT)
Discrete Wavelet Transform (DWT)
Discrete Fourier Transform (DFT)

3.4.1. Discrete Fourier Transform

Fourier Transform (FT) is an operation that transforms a continuous function into its frequency components. The equivalent transform for discrete valued function requires the Discrete Fourier Transform (DFT). In digital image processing, the even functions that are not periodic can be expressed as the integral of sine and/or cosine multiplied by a weighing function. Drawback is that it is complex to implement and require much computing time [13].

3.4.2. Discrete Wavelet Transform (DWT)

Wavelet Transform is a modern technique frequently used in digital image processing, compression, watermarking etc. The transforms are based on small waves called wavelet which has varying frequency and limited duration. A wavelet series is a representation of a square-integrable function by a certain ortho-normal series generated by a wavelet. The original signal can be completely constructed by performing Inverse Wavelet Transformation on these coefficients. Watermarking in the wavelet transform domain is generally a problem of embedding watermark in the sub bands of the cover image. In two dimensional applications, for each level of decomposition, firstly DWT in the vertical direction is performed, followed by the DWT in the horizontal direction. After the first level of decomposition, there are 4 sub-bands: LL1, LH1, HL1, and HH1. For each successive level of decomposition, the LL sub band of the previous level is used as the input. To perform DWT on 2 level DWT on LL1 is applied and for 3-Level decomposition DWT on LL2 is applied and finally 4 sub-band of 3 level that are LL3, LH3, HH3, HL3 as shown in Fig.3.

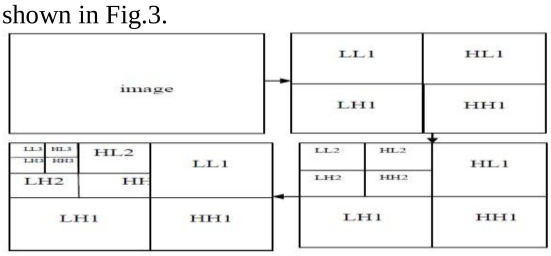

Figure.3 Embedding watermark in the sub-bands of cover image.

3.4.3. Decomposition Process

In the decomposition stage, the image is high and low-pass filtered along the rows and the results of each filter are down-sampled by two. Fig.4 shows one decomposition step of the two-dimensional gray scale image using DWT. The two sub-signals correspond to the high and low frequency components along the rows and each of size N by N/2. Each of the sub-signals is then again high and low-pass filtered, but this time along the column data. The results are again down-sampled by two. In this way the original data is split into four sub-images each of size N/2 by N/2 containing information from different frequency components [14].

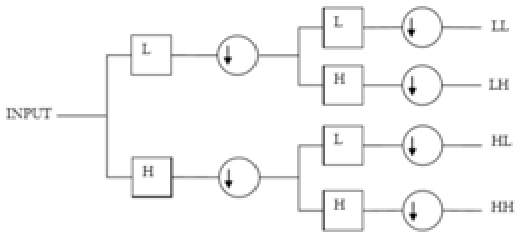

Figure.4 One Decomposition step of the two-dimensional image using DWT.

3.4.4. Reconstruction Process

The reconstruction process using IDWT is shown in Fig.5. Reconstruction means obtaining same image from the four sub-frequency bands. In this the information from four sub-bands is up-sampled and then filtered with the corresponding inverse filters using the columns. The two results are added and then again up-sampled and filtered with the corresponding inverse filters. The results from each step are added to form the original image [14].

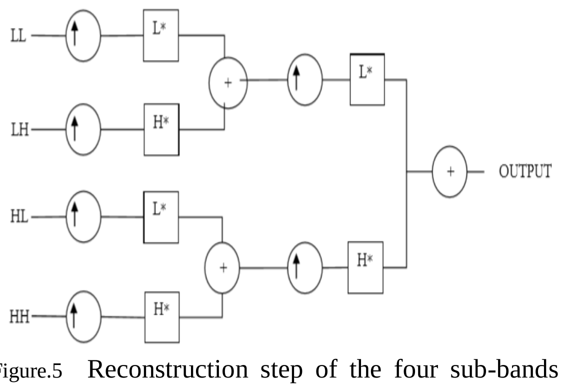

Figure.5 Reconstruction step of the four sub-bands using IDWT.

3.4.5. Discrete Cosine Transform (DCT)

Discrete Cosine Transform is related to DFT in a sense that it transforms a time domain signal into its frequency components. The DCT however only uses the real parts of the DFT coefficients. In terms of property, the DCT has a strong energy compaction property and most of the signal information tends to be concentrated in a few low-frequency components of the DCT. The JPEG compression technique utilizes this property to separate and remove insignificant high frequency components in images. A number of experiments are performed on the watermarked image to test the resilience of the proposed scheme towards common image processing attacks. 512x512 input gray scale image are used as cover image and watermark image respectively. These images are shown in following Fig.6,7,8,9.

Figure.6 Input image.

Figure.7 Watermarked image

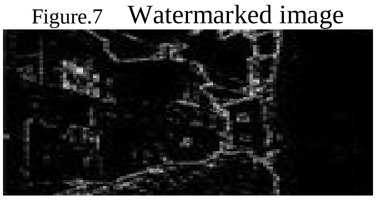

Figure.8 Extracted image.

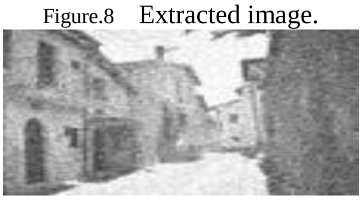

Figure.9 Corrupted image.

IV. PROPOSED ALGORITHM

4.1. Watermark Embedding Procedure

The original image is transformed into wavelet domain by applying a multi-DWT as shown in Fig.10. Based on the size of the image and the watermark, the number of decomposition levels is determined. If L is the number of levels, then 2L+2 of sub-bands are generated. In this proposed embedding process, four-level DWT decomposition is used. The challenge is to decide which sub-bands to use to embed the watermark. It is known that the human visual system is more sensitive to small perturbation in the lower-frequency bands than the higher ones. Therefore, keeping intact the middle frequencies assures that the watermarked image will be as close as possible to the original one. Therefore, successive wavelet decompositions use the middle-frequency bands. Select the cheque image. Decomposed the cover image of bank cheque into non overlapping multi- resolution sub-division bands like LLl, LHl, HLl and HHl on applying DWT. Again, decomposed the non-overlapping multi-resolution sub-division bands i.e. HLl sub-division bands is divided into four smaller sub-division bands and HL2 band are selected. The sub-division band HL2 is divided into 4x4 blocks. Discrete cosine transform is applied to every block in selected sub-division band HL2. Grey scale image of watermark is re-formulated into vector of one's & zeros. Create two pseudorandom sequences which are not similar to each other. One sequence is used to insert watermark bit 0 and other sequence is used to insert watermark bit 1. The elements present in PN_sequence should be exactly equal to the number of middle band frequency elements of DCT transformed DWT sub-bands PN_O and PN_I are the two pseudorandom sequences are used for embedding process with the help of gain factor k, in the DCT transformed 4x4 blocks of selected DWT HL2 sub-bands of the cover image of bank cheque. Watermark is not embedded in all frequency of DCT coefficient. After modification of its middle band frequency coefficient, inverse discrete cosine transform is applied for embedding watermark bits. To produce the watermark cover image of bank cheque the inverse discrete wavelet transform is applied on the DWT transformed image of cheque which includes the modified sub-division bands. The watermark embedding algorithm is outlined in Table.1.

Table. 1.Embedding Algorithm

Step 1: N- level DCT and DWT is applied to the cover image that is to be watermarked. **Step 2**: Meanwhile, PN sequence is applied to the secret image. **Step 3**: Embedded algorithm is applied to the cover image and secret image using a secret key. **Step 4**: IDCT and IDWT respectively is applied on the embedded image to get the watermarked image.

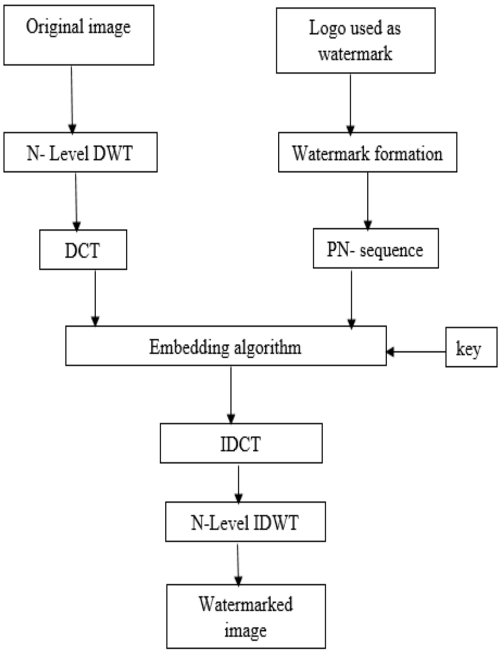

Figure.10 Combined DWT-DCT Watermark Embedding Procedure.

4.2. Watermark Embedding Procedure

The extraction process is the reverse of embedding as shown in Fig.11. It can be observed from the watermark permutation process that it prevents tampering or unauthorized access by attackers since only the owner of the image has the value of the key which is a necessary operand in the extraction operation. Select watermarked cheque image of bank**.** Decomposed the watermarked cheque image of bank into four different bands which are non overlapping multi-resolution band such as LLI, LH2, HLl, and HHI on applying DWT. Again decomposed the non-overlapping multi-resolution sub-bands i.e. HLl sub-division band is divided into four smaller sub-division bands and HL2 band are selected. HL2 sub-division band is divided into 4x4 blocks. Middle band frequency coefficients from each block of DCT transformed image are extracted from selected sub-division band of HL2 after DCT is applied to each block. The same seed are used to create again PN _0 and PN_l as two pseudorandom sequences which were utilized in watermark embedding process. Create two pseudorandom sequences PN_0 and PN_l and the correlation between the middle band frequency coefficient is calculated for each block in the sub-division band of HL2.The extracted bit of watermark is consider as I if the correlation with PN_0 is lower than PN_I, if not extracted bit of watermark is consider as 0. Calculate the similarity between the original watermark and extracted watermark by reconstruction of the watermark using extracted watermark bits. The watermark extraction algorithm is outlined in Table 2.

Table. 2.Extraction Algorithm

Step 1: N-level DWT followed by DCT is applied to the watermarked image.
Step 2: A PN- sequence along with key is applied to the secret image.
Step 3: Extraction algorithm is applied to both the images to get the extracted image.

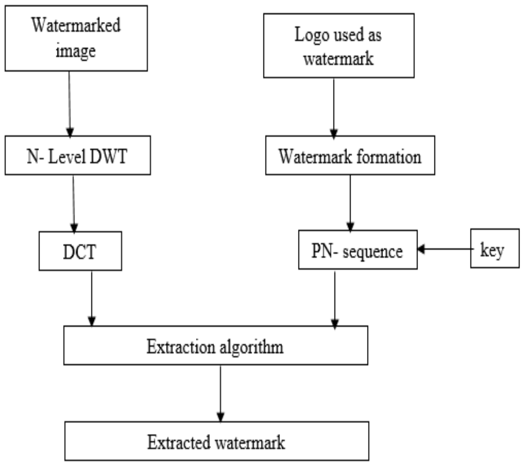

Figure.11 Combined DWT-DCT Watermark Extraction Procedure.

V. RESULT ANALYSIS

The quality of the resulting watermarked images is measured by Peak Signal to Noise Ratio (PSNR) using the Mean Square Error (MSE) as follows where I_1 is the original watermark, I_2 is the extracted watermark, and N and M are the width and height of the watermark [15]. The PSNR value is used as a measurement of the image degradation due to imbedding the watermark in the cover image. The performance of the watermarking methods can be measured by imperceptibility and robust capabilities. From the existing system image quality measured by PSNR among the watermarked images were larger than 42 db. This PSNR is calculated by using equation (3).

PSNR (dB): 10 Log10 {Max2/MSE} (3)

Watermarked image quality is measured in terms of imperceptibility. Cover image of cheque quality should not disturb due the presence of watermark. However, peak signal to the noise ratio i.e imperceptibility is calculated in decibels (dB) [16]. The corresponding PSNR and MSE values are listed in Table 3 along with the estimated embedding and extraction time. The imperceptibility is calculated by using equation (4)

MSE: $\sum_{M,N} [I_1(m,n)-I_2(m,n)]^2 / M*N$ (4)

Generally, if PSNR value is larger than 40 db the watermarked image is within acceptable degradation levels, i.e. the watermarked is almost invisible to human visual system. A lower mean absolute error reveals that the extracted watermark w0 resembles the w1 more closely.

5.1 Experimental results

The experimental results are simulated with the software MATLAB R2014a version. It provides a single platform for computation, visualization, programming and software development. All problems and solutions in MATLAB are expressed in notation used in linear algebra and essentially involve operations using matrices and vectors. Select a cheque image, apply DWT to decompose the cover host image into four non-overlapping multi-resolution sub-bands: LL1, HL1, LH1, and HH1. Again DWT is applied to sub-band HL1 to get four smaller sub-bands and choose the HL2 sub-band, apply DWT to sub-band HH1 to get four smaller sub-bands and choose the HH2 sub-band further divide the sub-band HL2 (or HH2) into 4 x 4 blocks and later apply DCT to each block in the chosen sub-band (HL2 or HH2).

Table. 3. Values of PSNR and MSE values with Embedding and Extraction time.

Cheque images	MSE value	PSNR value(in dB)	Embedding time(in sec)	Extraction time(in sec)
SBI	9.385881e-01	44.46	2.0537	0.40869
HDFC	9.909821e-01	44.22	1.9962	0.4099
Private	1.308261e+00	53.01	1.9979	0.40645
Bank of Baroda	4.304181e-01	47.84	2.0342	0.40817
Canara	6.342639e-01	46.16	1.9707	0.40902
ICICI	1.597450e+00	52.15	2.0935	0.41415
Axis	5.566314e-01	46.72	1.9995	0.41203
HSBC	1.064723e+00	53.91	2.0063	0.41634
Union	2.100184e+00	50.96	17.8414	0.55679

Re-formulate the grey-scale watermark image into a vector of zeros and ones [17].

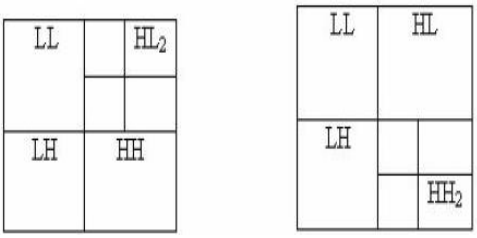

Figure.12 Grey- scale watermark image.

Generate two uncorrelated pseudorandom sequences is shown in Fig.12. One sequence is used to embed the watermark bit 0 and the other sequence is used to embed the watermark bit 1. Number of elements in each of the two pseudorandom sequences must be equal to the number of mid-band elements of the DCT-transformed DWT sub-bands. Embed the two pseudorandom sequences and with a gain factoring the DCT transformed 4x4 blocks of the selected DWT sub-bands of the host image. Embedding is not applied to all coefficients of the DCT block, but only to the mid-band DCT coefficients. If we donate **X** as the matrix of the mid band coefficients of the DCT transformed block, then embedding is done. At the extraction apply inverse DCT (IDCT) to each block after its mid-band coefficients have been modified to embed the watermark bits as described in the previously and apply the inverse DWT (IDWT) on the DWT transformed image, including the modified sub-band, to produce the watermarked host image.

Different cheque images along with their secret images are considered and 4-level DWT computation is applied on these images. Later embedding algorithm is used to watermark embedded image. At the extraction process, embedded watermark image is used to extract the secret image. All the respective images are shown in Fig.13, 14,15.

Figure.13 Embedding and extraction of watermark for different images.

Figure.14 Embedding and extraction of watermark for different images.

Figure.15 Embedding and extraction of watermark for different images.

5.2 Performance Comparison

For performance comparison, another existing digital watermarking schemes were considered which was proposed by Sleit [18], Satyanarayana [19], Suresh [20] and Arashdeep [21] and values are listed in Table.4 with respect to proposed and existing system. The results discussed in the below section have been simulated using MATLAB for the gray scale Lena, Barbara, Baboon, Boat, Lake, Mandrill, Pirate and Pepper images of size 512 × 512. For watermark, copyright gray scale image and cameramen gray scale image of size 128 × 128 was used in existing system while grey scale of size 512x 512 is used in proposed system and respective PSNR values for both the systems are listed accordingly.

Table. 4.Comparison of PSNR values

Authors	Images (PSNR values)							
	Lena	Barbara	Pirate	Mandrill	Peppers	Boat	Lake	Baboon
Sleit et.al.,[18]	55.6	47.9016	-	-	-	-	-	45.1308
Satyanarayana et.al.,[19]	47.42	-	45.06	44.97	44.20	44.41	48.35	-
Suresh et.al.,[20]	42.7983	-	-	-	43.7983	-	44.5289	-
Arashdeep et.al.,[21]	39.17	-	-	30.83	33.32	-	-	-
Proposed	47.03	46.76	45.82	46.76	47.24	47.11	47.14	46.60

VI. CONCLUSION

Combined DCT-DWT Digital Watermarking Technique Software Used for CTS of bank is explained in this paper. The DCT and DWT provide high robustness and imperceptibility to the cheque image. This software provides security, copyright protection and data authenticity to cheque image. In this paper, it also describes a digital image watermarking algorithm based on combining two transforms; DWT and DCT. Watermarking is done by altering the wavelets coefficients of carefully selected DWT sub-bands, followed by the application of the DCT transform on the selected sub-bands. Different kinds of attacks, such as image resampling and image rotation with use of different algorithms are still challenging to the current work, and have been chosen to be the major direction of the future work.

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