Advanced Image Watermarking Methods with Enhanced Security using Hybrid Mechanism

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Abstract: Image watermarking is a signal that is embedded in a image data permanently such that it can be extracted by dewatermarking using some operations for checking the authenticity of data or user. The watermark is inseparable from the host image and it should be robust enough to resist any modifications along with preserving the image quality. In this way the watermarking helps in keeping intellectual properties to be accessible while keeping them permanently water marked. In our proposed work we have focused on watermarking techniques and checked their robustness against environmental distortions during the storage and transmission of watermarked image. In this work we have applied a hybrid SVD-DCT-DWT watermarking approach in gray biomedical image watermarking to develop a robust algorithm against several image attack. We have also compared our algorithm with two different watermarking technique named as DCT-SVD,DWT-DCT.

Keywords-- Watermarking, image processing, DCT, DWT, SVD and image encryption, security.

1. Introduction:

Discrete Wavelet Transform (DWT) is a multi-resolution analytical approach of time-frequency and can describe partial characteristics of time and frequency domains. The basic thought is to decompose the image to sub images with different space and frequency, then, the coefficient is processed.

The DWT can be implemented as a multistage transformation. An image is decomposed into four sub bands denoted LL, LH, HL, and HH at level 1 in the DWT domain, where LH, HL, and HH represent the finest scale wavelet coefficients and LL stands for the coarse-level coefficients.

1D Discrete Wavelet Transform

Wavelet can represent a signal in time-frequency domain. Analysing a signal with this kind of representation gives more information about the when and where of different frequency components. In other words, wavelet transform not only transforms the time domain representation of a signal to the frequency domain representation, but also preserves spatial information in the transform. This feature enhances the image quality especially for the low bit rate representation. The DWT is a multi-resolution technique that can analyse different frequencies by different resolutions. The low-pass and high-pass filter pair is known as analysis filter-bank.

An example of a low-pass filter is $h0(n) = (-1, 2, 6, 2, -1)/8$, which is symmetric and has five integer coefficients. An example of a high-pass filter is $h1(n) = (-1, 2, -1)/2$, which is also symmetric and has three integer coefficients. These low- and high pass filters are used in the (5, 3) filter transform.

After applying the 1D DWT on a signal that has been decomposed into two bands, the low-pass outputs are still highly correlated, and can be subjected to another stage of two-band decomposition to achieve additional decor relation. In addition, the 1D DWT can be easily extended to two dimensions (2D) by applying the filter-bank in a separable manner. At each level of the wavelet decomposition, each row of a 2D image is first transformed using a 1D horizontal analysis filter-bank (h0, h1). The same filter-bank is then applied vertically to each column of the filtered and sub-sampled data.

2D Discrete Wavelet Transform

The 2D DWT is computed by performing low-pass and high-pass filtering of the image pixels as shown in Figure 3.4. In this figure, the low-pass and high-pass filters are denoted by h and g, respectively. This figure depicts the three levels of the 2D DWT decomposition. At each level, the high-pass filter generates detailed image pixels information, while the low-pass filter produces the coarse approximations of the input image.

At the end of each low-pass and high-pass filtering, the outputs are down-sampled by two (↓ 2). In order to provide 2D DWT, 1D DWT is applied twice in both horizontal and vertical filtering. In other words, a 2D DWT can be performed by first performing a 1D DWT on each row, which is referred to as horizontal filtering, of the image followed by a 1D DWT on each column, which is called vertical filtering.

There are different approaches to implement 2D DWT such as traditional convolution-based and lifting scheme methods. The convolution methods apply filtering by multiplying the filter coefficients with the input samples and accumulating the results. Their implementation is similar to the Finite Impulse Response (FIR) implementation.

This kind of implementation needs a large number of computations.

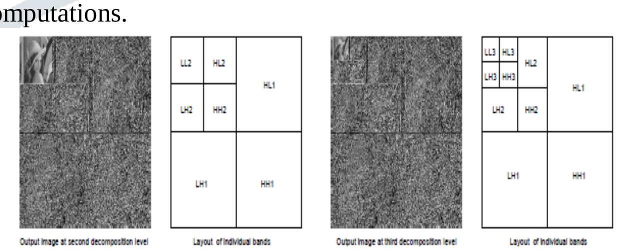

Fig 1: Sub-band after second and third decomposition levels

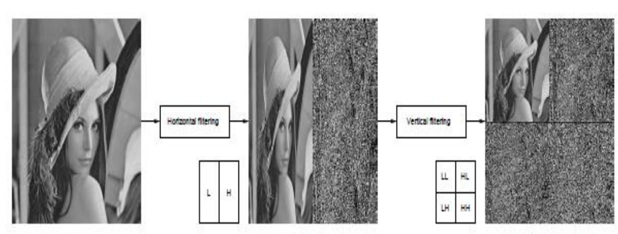

Fig 2: Different sub-bands after first decomposition level

2. Related Work:

In 2000, Chiou-Ting Hsu et. Al. (IEEE), proposed their work related to image watermarking by wavelet decomposition. In this work, they stated that, digital watermarking has been increasingly recognized as a highly effective means of protecting the intellectual property rights associated with multimedia data. Based on the multi-resolution structures of wavelet decomposition, both, on a real field and binary field, a multi-resolution watermarking technique was proposed. Since the Human Visual System (HVS) inherently performs a multi-resolution structure, each decomposed layer of a binary watermark is embedded into the corresponding decomposed layer of a host image. Therefore, in case of attacks or progressive transmission, the coarser approximation of a watermark is preserved in the coarser version of an image. In a progressive transmission, adding higher frequency components, allows us to obtain higher resolution image, and, correspondingly, extract a higher resolution watermark. There experimental results demonstrated the robustness and validity of the watermarking process.

In 2005,Maha Sharkas et. Al. (IEEE) proposed their work related to dual digital-image watermarking technique. In their work, they presented that image watermarking has become an important tool for intellectual property protection and authentication. In this work a watermarking technique was suggested that incorporated two watermarks in a host image for improved protection and robustness. A watermark, in form of a PN sequence (will be called the secondary watermark), was embedded in the wavelet domain of a primary watermark before being embedded in the host image. The technique has been tested using Lena image as a host and the camera man as the primary watermark. The embedded PN sequence was detectable through correlation among other five sequences where a PSNR of 44.1065 db was measured. Furthermore, to test the robustness of the technique, the watermarked image was exposed to four types of attacks, namely compression, low pass filtering, salt and pepper noise and luminance change. In all cases, the secondary watermark was easy to detect even when the primary one was severely distorted.

In 2006 Chih-Yang Lin et. Al proposed their work related to robust image hiding method using wavelet technique. There work stated that a robust wavelet-based image hiding methods, that hide still images, E, inside a covered image, C, to establish a composite image, P, are presented. We can hide up to three full-size embedded images inside a cover image while maintaining the quality of the composite image. The embedded images retain easily recognizable when extracted. The embedded images can be extracted fairly completely even when lossy compression or cropping is applied to the composite image. The proposed method does not require the original cover image to extract the embedded image.

In 2007 Ibrahim Nasir et. Al (IEEE) proposed their work related to a new robust watermarking scheme for color image in spatial domain. This work presented a new robust watermarking scheme for color image based on a block probability in spatial domain. A binary watermark image was permutated using sequence numbers generated by a secret key and Gray code, and then embedded four times in different positions by a secret key. Each bit of the binary encoded watermark was embedded by modifying the intensities of a non-overlapping block of 8*8 of the blue component of the host image. The extraction of the watermark was by comparing the intensities of a block of 8*8 of the watermarked and the original images and calculating the probability of detecting '0' or '1'. Tested by benchmark Stirmark 4.0, the experimental results showed that the proposed scheme was robust and secure against a wide range of image processing operations.

In 2007, Chin-Chen Chang et. Al. presented there work related to an SVD oriented watermark embedding scheme with high qualities for the restored images. In this work, they stated that SVD-based watermarking scheme, which successfully embeds watermarks into images, and its hidden watermarks can resist various attacks. In this work, we further extended their idea so that the hidden watermarks can be removed to provide authorized users better image quality for later usage after the ownership of purchased images has been verified. To achieve our objective, we modified their embedding strategy, and the extra information required for later restoration is embedded into the least important non-zero coefficients of the S matrices in the image. Experimental results confirmed that our scheme not only provided good image quality of watermarked images but also successfully restored images with high restoration quality.

3. Methodology:

The proposed DWT-SVD watermarking scheme is formulated as given here.

1) Perform one-level Haar Discrete Wavelet Transform which is used to divide the cover image I into four non-overlapping multi-resolution sub bands (i.e., LL, LH, HL, and HH).

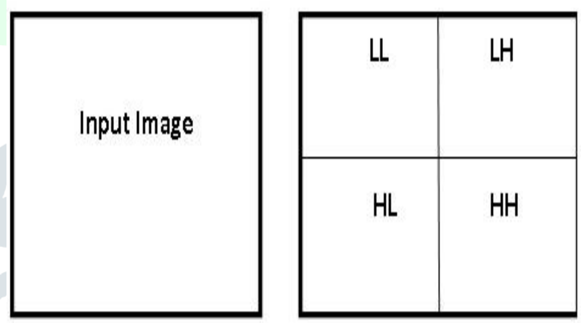

Fig. 3: input image and one level Haar DWT

2) Now Perform Singular Value Decomposition to LH and HL sub bands, i.e.,

$I_n = U_n S_n V_{nT}$, $n = 1, 2$ (1)

Where n represents one of two sub bands.

3. Decompose the watermark image into two parts: $W = W_1 + W_2$,

Where W_n denotes half of the watermark.

4) Modify the singular values in HL and LH sub bands with half of the watermark image and then apply SVD to them, respectively, i.e.,

$S_n + \alpha * W_n = U_{nw} S_{nW} V_{nTW}$ (2)

Where α denotes the scale factor. The scale factor is used to control the strength of the watermark to be inserted.

5) Apply the given method to obtain the two sets of modified DWT coefficients, i.e.,

$I_{*n} = U_n S_{nW} V_{nT}$, $n = 1, 2$ (3)

6) Now by performing the inverse DWT, obtain the watermarked image IW using two sets of modified DWT (i.e. LH & HL) coefficients and two sets of unmodified DWT(LL & HH) coefficients.

DCT – SVD

STEP 1 :- Define block size = 8/4 (for DCT) and define multiplying factor a=10

STEP 2:- Read host image and water mark image (H,W).

STEP 3:- Calculate rows & columns of H and W and calculate no. Of blocks,

Block count = (rows * columns)/(block size)2

STEP 4:- Take 2D DCT of host image blocks cb (cb= DCT blocks of H)

STEP 5:- Apply SVD on DCT block [U,S,V] = svd(cb)

STEP 6:- Takes the block of W and mix them with the S component of DCT of host image.

STEP 7:- Perform SVD of sm. [U1,S1,V1] = svd(sm)

STEP 8:- Reconstruct the image from UV of DCT(host image) and S1 of mixed watermarking image.

CM= U*S1*V

STEP 9:- Perform rearranging of the blocks of CM to get the watermarked image.

STEP 10:- Add Noise to the watermarked image [WM]. To get [WM] noisy.

DE- WATERMARKING

STEP 1:- Break the [WM] in predefined blocks and apply 2D DCT on these blocks.

STEP2:- Apply SVD on DCT blocks.

[U,S,V]=svd(cb)

STEP3:- Break the watermarked image into the blocks (cbm) and apply SVD on these blocks.

[Um,Sm,Vm] = svd (cbm)

STEP 4:- Now perform reconstruction of extracted watermarked image by following eq:-

Sl =[U1*Sm*V]

Wbm= extracted watermarked block = (Sl - S)/a.

STEP5:- Arrange the blocks of Wbm to reconstruct the extracted watermarked image.

DWT-SVD

STEP1:- STEP 1 :- Define block size = 8/4 (for DCT) and define multiplying factor a=10

STEP 2:- Read host image and water mark image (H,W).

STEP 3:- Calculate rows & columns of H and W and calculate no. Of blocks,

Block count = (rows * columns)/(block size)2

STEP 4:- Take the DWT of host image to get [CA1,CH1,CV1,CD1] image component, representing A as Approximation, H as Horizontal details, V is vertical details and D are Diagonal details.

STEP 5:- Apply DCT on the blocks of [CD1] to get dct_block matrix.

STEP 6:- ADD the pixel intensity of water marked image to the dct vale of each dct_block.

Dc value|DCT_blockij = dc value|DCT_blockij + a*Wij

STEP 7:- Reconstruct the diagonal component by taking inverse dct of each dct blocks and save as

CD1w.

STEP 8:- Apply inverse dwt on [CA1,CH1,CV1 and CD1w] to generate watermarked image [Wm]

Watermarked image = idwt[CA1,CH1,CV1,CD1w].

DE-WATERMARKING

STEP 1:- Apply DWT on Wm [CAM1,CHM1,CVM1 & CDM1]=dwt (Wm)

STEP 2:- We can recover water marked image by following eqn-

Dct(CDM1) -> dct_blockw

Watermark_extracted = dct_blockw – dct_block/a=WME

STEP 3:- By re-arranging the WME pixels after each dctblock processing we can recover water

Marked image.

DWT-DCT-SVD

STEP 1 to 6 same as DCT-SVD

STEP 7:- Collect all the DC values of the DCT matrices to form a new matrix named as [DC]

STEP 8:- Perform the SVD of DC matrix.

[U1,S1,V1]=svd[DC]

STEP 9:- Mix the value of watermarked pixel to the S1 component.

Sm=S1+a(*W)

STEP 10:- Again perform the svd[Sm] as given below:

[U2,S2,V2]=svd[Sm]

STEP 11:- Mixed the S2 with (U1,V1) to regenerate pdated DC matrix by following eqn:-

DCM=U1*S2*V1

STEP 12:- Now perform inverse dct for dct_block updated with DCm,to obtain [CD1w].

STEP 13:- Arrange the DCT blocks and apply IWT on [CA1,CH1,CV1 & CD1w] to generate water

Marked image Wm.

WM= idwt(CA1,CH1,CV1,CD1)

DE-WATERMARKING

STEP 1:- Take DWT of Wm as given below:-

[Cam1,CHm1,CVm1,CDm1]=dwt[Wm]

STEP 2:- Apply dct on CDm1 block.

dct[CDm1] dct_blockw

STEP 3:- Generate the DC value matrix from dct block W named as [DCW] and apply svd on this Matrix sing following eqn:

[Um,Sw,Vm]=svd[DCW]

STEP 4:- Combine U2 and V2 svd component with Sw as given below:-

E=U2*Sw*V2

STEP 5:- Generate extracted water marked image by following eqn:-

WME=E-S1/a.

Proposed Model:

In this work the combined approach of image watermarking which have been used that satisfies two requirements i.e. imperceptibility and robustness. We have used combination of discrete wavelet transform (DWT), discrete cosine transform (DCT) and singular value decomposition to achieve the above requirements. As well as, the watermark image is embedded directly on the elements of singular values of the original image's DWT sub bands.

The proposed system is the combination of our different modules, they are as follows:

1. Watermark of image using DCT-SVD/ DWT-SVD/ DWR-DCT-SVD.
2. Application of attacks on watermarked image.
3. Extraction of the watermark image from the original image.

4. Measurement of PSNR and normalization coefficient.

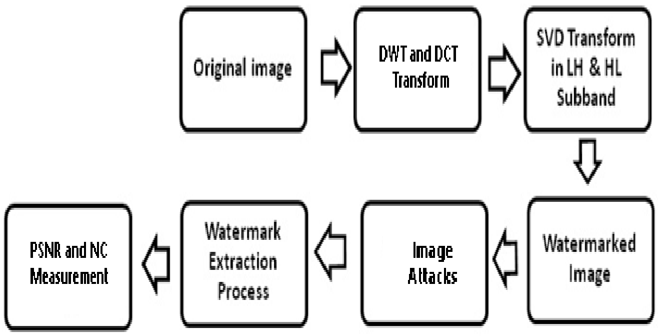

Fig. 4: Proposed Model

4. Result and Discussion:

In this section we have shown the results of our watermarking algorithms in absence and presence of image attacks. We have taken image named as host1.jpg as a host image under which we have to hide our watermark images wm1.png and wm2.png. The host1 image is shown in fig 5.

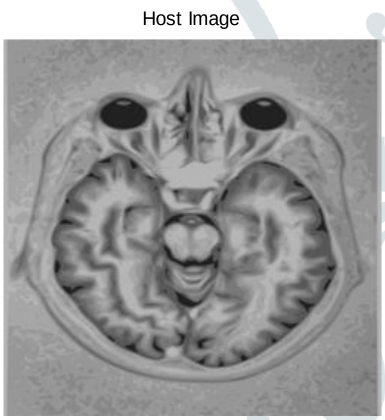

Fig 5: Original Image.

DCTDWTSVD Gaussian Noise based image watermarking/Dewater marking:

We have applied our DCTDWTSVD noise algorithm on host1 image (fig 6 (a)) to watermark the image wm1 (fig 6 (d)). The image obtained after watermarking that is watermarked image is shown on fig 6 (b). Then Gaussian image (fig 6 (c)) attacks is apply on watermark image and it is Dewater marked and its extracted watermarked image is shown in fig 6(e)

Fig 6 (a): Original Image.

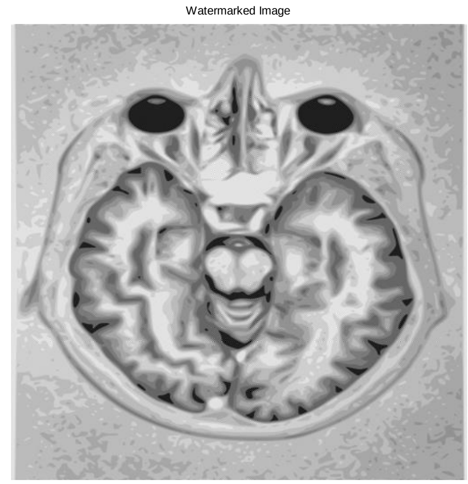

Fig 6(b): Watermarked Image.

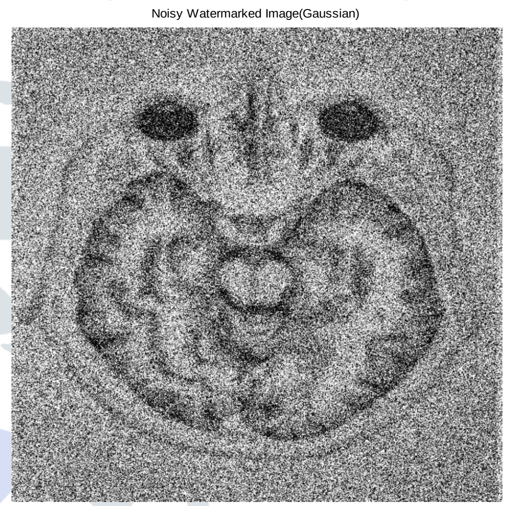

Fig 6(c): Noisy Watermarked Image

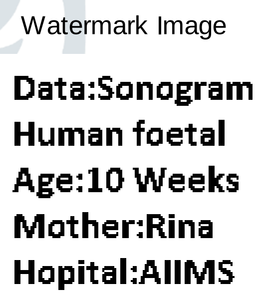

Fig 6(d): Watermark Image.

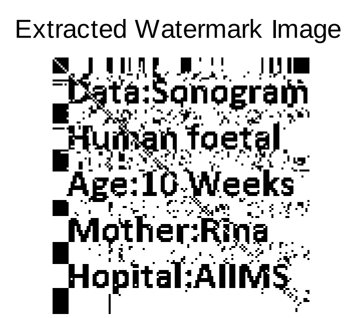

Fig 6(e): Extracted Watermarked Image.

5. Conclusion:

The results suggests that DC-SVD-DWT based watermarking scheme is giving best performance in the presence of recovery of watermark image used to indicates the text based data of

biomedical images. The results are verified analytically in terms of PSNR and normalization coefficients and both are found high for novel DCT-DWT-SVD watermarking scheme.
In future the work can be extended for considering other image attacks effect and code parameter optimization in terms of additional image attacks. Presently we have considered the algorithm robustness for salt and pepper noise and Gaussian noise. In future effects of compression, transformation and cropping can also be considered for demonstrating the performance of developed watermarking scheme.

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