An Efficient JND based Digital Image Watermarking using Hybrid DWT-DCT-SVD Approach

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Abstract—Digital watermarking is an effective approach to afford copyright fortification. Watermark transparency is obligatory primarily for copyright protection. By using the characteristics of human visual structure, the just noticeable distortion (JND) can substantiate the transparency condition. This paper aims at developing a hybrid image watermarking technique which satisfies both imperceptibility and robustness requirements. To achieve objectives we used singular values of Transformation's (DWT-DCT) sub bands to insert watermark. Further to increase and control the strength of the watermark, this work used an efficient JND model. An optimal watermark embedding method is developed to achieve minimum watermarking distortion. Experimental results are provided in terms of Peak signal to noise ratio (PSNR), Mean Squared Error (MSE), Correlation and Weighted Peak signal to noise ratio (WPSNR) to demonstrate the effectiveness of the proposed technique.

Keywords—Just Noticeable Distortion; Digital Watermarking; multi-scale embedding; Wavelet subspaces; Singular Value Decomposition; Discrete Wavelet transform; Discrete Cosine Transform.

I. INTRODUCTION

Digital media offers many distinct benefits over analog media, like high quality, simple editing, high performance and effortless duplication. The high spreading of broadband networks and new developments in digital technology has created ownership protection and authentication of digital multimedia system a really vital issue. Digital watermarking provides a potential solution to the matter of simple editing and duplication of pictures, since it makes feasible to identify the author of an picture by embedding secret data in it.

Digital watermarking technique is one in all the solutions to avoid illegal use or tampering of multimedia information. Recently several watermarking schemes are projected to deal with this downside. Watermarking is defined as the process of hiding a piece of digital data in the cover data which is to be protected and extracted later for ownership verification [1], a basic watermarking system is shown in figure 1. Some of the vital applications of watermarking technique are finger printing, copyright protection, proof of ownership, broadcast monitoring and covert communication. The characteristics of watermarking include robustness and perceptibility. Robustness shows the resistivity of watermark against different kinds of attacks like cropping, rotating, scaling, low pass filtering, resizing, and addition of noise, JPEG compression, sharpness, contrast adjustment and histogram equalization. Those attacks are either planned or unplanned. Robustness is the property which is essential for ownership verification whereas the fragility is very important for image authentication.

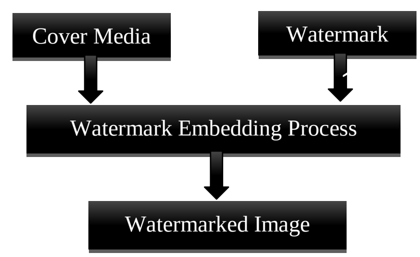

Figure 1.Flow of Watermarking process

Robustness of watermarking technique is obtained to a maximum level when information is hidden in robust components of original image. The increasing visibility will also decrease the quality of watermarked image. Broadly watermarking schemes are categories into two main domains i.e. transform domain and the spatial domain. In spatial domain watermarking the watermark is embedded by directly modifying the intensity values of the original image.. In transform domain the watermark is embedded by modifying the frequency coefficients of the transformed image.

The common methods in the transform domain are discrete wavelet transform (DWT), Fourier transform (DFT), discrete cosine transform (DCT), etc. Recently, singular value decomposition (SVD) was explored for watermarking. SVD is one of the most useful numerical analysis techniques having property that the singular values (SVs) of an image do not change significantly when a small perturbation is inserted to an image. [2-5].

Just-noticeable distortion (JND), refers to the maximum distortion that the human visual system (HVS) cannot observe, plays an vital role in perceptual image and video processing. In most circumstances, the human visual system (HVS) makes final evaluations on the quality of images and video that are processed, transmitted, and displayed. Thus, it is essentially futile to spend significant effort on encoding those signals that are beyond the human perception. Just noticeable distortion (JND), which accounts for the maximum distortion that the HVS does not perceive, can serve as a perceptual threshold to guide an image/video processing task. In image compression schemes, JND can be used to optimize the quantizer or to facilitate the rate-distortion control. Information of higher perceptual significance is given more bits and preferentially encoded, so that the resultant image is more appealing.

It is well known that there are three main mutually conflicting properties of information hiding schemes: capacity, robustness and indefectibility [6]. It can be expected that there is no a single watermarking method or algorithm with the best quality in the sense that three mentioned above properties have the maximum value at once. But at the same point it is obvious that one can reach quite acceptable quality by means of combining various watermarking algorithms and by means of manipulations in the best way operations both in the spatial and in the frequency domains of an image. In paper [7] an approach to combining of DWT and DCT to improve the performance of the watermarking technique, which are based only on the DWT, is proposed. Watermarking was done by embedding the watermark in the first and second level DWT sub-bands of the cover image, followed by the application of DCT on the selected DWT sub bands. The combination of these two transforms improved the watermarking performance considerably when compared to the DWT-only watermarking approach. As a result this approach is at the same time resistant against copy attack.

Robustness is the property which is important for ownership verification whereas the fragility is important for image authentication. Robustness of watermarking technique is obtained to a maximum level when information is hidden in robust components of cover data. The increasing visibility will also decrease the quality of watermarked image. In general information could be hidden, directly by modifying the intensity value or pixel value of an image or its frequency components [8]. The former technique is called spatial domain technique and later is called frequency domain technique. To get frequency components of an image, it needs to be transformed using any one of the transformation techniques such as Discrete Fourier Transformation (DFT), Discrete short Fourier transformation (DSFT), Discrete Cosine Transformation (DCT) [9][10], Walsh Hadamard transformation (DHT) [11][12], and Discrete wavelet Transformation (DWT)[13][14][15][16]. In Transform domain casting of watermark can be done in full frequency band of an image or in specific frequency band such as in low frequency band or in high frequency band or in middle frequency band.

A. *Structure of Assessment*

The association step of this paper is as follows. The Introductory Section ends with a introduction of digital watermarking and its necessity in copyright protection.

In Section II, explains a General review and related work of digital image watermarking, many techniques have been proposed for the digital watermarking which are categorized in this section.

Section III addresses the proposed methodology and system model along with the technical specifications of proposed work including the steps of work and block diagram of both the embedding and extraction process.

Section IV gives details about the simulation results; it also shows some comparative graphs which prove that the proposed approach overcome the traditional DWT-DCT based approach.

Section V shows the discussion, observations and a general conclusion of the paper are presented.

II. RELATED WORK

Watermarking is a process that hides information into a host image for the purpose of copyright protection, integrity checking, or captioning [1–3]. In order to achieve the transparency of watermark, many generally used techniques are based on the characteristics of human visual system (HVS) [1–13].

In [14], two level decomposition of DWT is applied to transform an image into bands of different frequency and a particular band is converted into blocks of size 4x4 for embedding data. In [15] the DWT is combined with SVD technique to hide data in high frequency band of an image. This technique performs well for variety of image processing operations. Lahouari Ghouti [17] have proposed a new perceptual model, which is only dependent on the image activity and is not dependent on the multi-filter sets used.

Satisfying both imperceptibility and robustness for an image watermarking technique always remains a challenge because both are conflicting requirements. Since performing SVD on an image is computationally expensive, a hybrid SVD-DWT-based watermarking technique is developed that requires less computation effort yielding better performance. Rather than embedding watermark directly into the wavelet coefficients, Chih-Chin Lai have proposed to embed watermark in to the elements of singular values of the image's DWT sub bands. [18]

In order achieve both image authentication and protection simultaneously, Chun-Shien Lu [19] proposes a cocktail watermarking which can resist different kinds of attacks and embed 2 watermarks (fragile & robust). Existing systems used invariant properties of DCT coefficients and relationships between the coefficients for watermark embedding but they modify a large amount of data and produces maximum distortion. So a new method that uses Gaussian mixture model, secret embedding key and private key for watermark embedding is proposed by Hua Yuan and Xiao- Ping Zhang [20].

Though there are existing systems that provides perceptual invisibility and robustness, YiweiWang [21] have proposed a new wavelet based technique for ownership verification by giving importance to the private control over the watermark and using randomly generated orthonormal filter banks. Liehua Xie [22] have proposed a concept of using compression algorithms based on wavelet decompositions. In this work, the SPIHT compression algorithm is executed to obtain a hierarchical list of the significant coefficients.

Mauro Barni [23] have proposed a new algorithm different from other existing systems in wavelet domain where the masking is performed pixel by pixel by taking into account the texture and the luminance content of all the image sub bands. A blind watermarking scheme that is robust against Gaussian noise, JPEG compression, median filtering, salt and pepper noise, and Conv-Filter attacks was proposed by Ning Bi, Qiyu Sun [24]. This new approach uses Multiband wavelet transform and they embed the watermark bits in the mean trend of some middle-frequency sub images in the wavelet domain.

T. M. Ng [25] uses a Laplacian model in place of Gaussian distribution along with the ML detection for improved performance. Existing systems make use of wavelet coefficients and embed watermark bits directly into the coefficients whereas the system proposed by Shih-Hao Wang [26] groups the wavelet coefficients into super tress and embed watermarks by quantizing super trees.

Generally, existing wavelets have limited ability to reveal singularities in all directions. So Xinge You [27] constructs the new non-tensor product wavelet filter banks, with this singularities in all directions is capture. A novel multipurpose digital image watermarking method [28] Has been proposed based on the multistage vector quantizer structure, which can be applied to copyright protection and image authentication applications.

Jayant et al. [31, 32] introduced a key concept known as the just noticeable distortion (JND), against which insignificant errors are not perceptible by human eyes. The JND of an image is in dependent on contrast of luminance, background luminance and dominant spatial frequency. As noted, human visual perception is sensitive to the contrast of luminance rather than their individual values [33–35]. In addition, the visibility of stimuli can be reduced by non-uniformly quantizing the background luminance [35–37]. The above known as the texture masking effect and the spatial masking effect are key factors that affect the JND of an image. Chou and Li proposed a model called the full-band JND model [38].

III. PROPOSED WATERMARKING SCHEME

This paper develops a hybrid digital image watermarking algorithm which satisfies both imperceptibility and robustness requirements. In order to achieve objectives this research used singular values of Transformation's (DWT-DCT) sub bands to embed watermark. Further to enhance and control the strength of the watermark, this work used an efficient JND model. First both the cover image and watermark are transformed through discrete wavelet transform, and then the maximum information carrying LL band is further transformed through discrete cosine transform. Then the proposed model calculated the singular values of transformed part of both cover image and watermark image using singular value decomposition. After that, the singular values are combined with each other by taking JND factor between cover image and watermark image in order to evolve a more promising approach in field of digital image watermarking.

The watermarking schemes proposed here are combined DCT/DWT based processes, where the benefits of DWT are taken into consideration in choosing the most proper sub-band for watermark embedding in order to provide both robustness and imperceptibility and hence the LL sub-band is chosen after performing one level DWT on the host image. Secondly, DCT is applied on the DWT sub-bands and for watermark embedding purpose the middle frequency DCT coefficients are selected to provide further robustness to the schemes.

The Wavelet Series is just a sampled version of continuous WT and its computation may consume significant resources and amount of time, depending on the resolution required. The Discrete Wavelet Transform (DWT), which is based on sub-band coding, is found to yield a fast computation of Wavelet Transform. It is easy to reduce and implement the computation time and resources required. The DWT is computed by successive low-pass and high-pass filtering of the discrete time-domain signal. This is called the Mallat-tree decomposition. Its importance is in the manner it connects the continuous-time multi-resolution to discrete-time filters. The DWT decomposes input image into four components namely LL, LH, HL and HH where the first letter corresponds to applying either a low pass frequency operation or high pass frequency operation to the rows, and the second letter signifies the filter applied to the columns. At each decomposition level, the half band filters produce signals spanning only half the frequency band. The 2D-DCT can not only concentrate the main information of original image into the smallest low frequency coefficient, but also it can reduce the block artifacts, which can realize the good settlement between the information centralizing and the computing complication. So it obtains the wide spreading application in the compression coding.

A. Discrete Wavelet Transform (DWT) and Singular Value Decomposition (SVD)

DWT decomposes images into four bands. In this work, the watermark is embedded in maximum energy bands (means all frequencies). And after that, all bands are further transformed using discrete cosine transform, these results in robustness to a wide range of attacks. SVD is an optimal matrix decomposition technique. It packs maximum energy into as few coefficients as possible. SVD has the ability of adapting to variations in local statistics of an image. So, watermarking schemes using SVD are typically of large capacity. Different types of wavelets are also used in experiment including 'db1' or Haar Wavelet, 'db2' or Daubechies level two wavelets, 'db4' or Symlets level two wavelets, or 'dmey' Daubechies level four wavelets, 'sym2' or Discrete Meyer wavelets and 'db45' or Daubechies level 45 wavelets

B. General review of Singular Value Decomposition

Singular value decomposition is a linear algebra technique used to solve many mathematical problems [29]. In image processing applications the theoretical background of SVD technique to be noticed is [30]:

a) The SVs (Singular Values) of an image has very good stability, which means that when a small value is added to an image, this does not affect the quality with great variation.

b) SVD is able to productivity represent the intrinsic algebraic properties of an image, where singular values correspond to the brightness of the image and singular vectors reflect geometry characteristics of the image.

c) An image matrix has many small singular values compared with the first singular value. Even ignoring these minute singular values in the reconstruction of the image does not affect the quality of the reconstructed image.

C. A human visual model for DCT-DWT-SVD domain image Watermarking

A relationship between a hybrid DCT-DWT domain human visual model and the modification threshold of singular values is established. The threshold, which in image adaptive, is used to determine the watermarking strength and guarantees the imperceptibility of the watermark.

D. Just-Noticeable Distortion (JND):

For the calculation of spatial domain Just Noticeable Distortion (JND) profile for a given image following model is used.

This model can compute the JND profile for a 4 level DWT decomposition. $I^{r,s}(x,y)$ Denotes the waveletcoefficient at position (x,y) of decomposition level $r \in \{0,1,2,3\}$ and orientation $s \in \{LL, LH, HL, HH\}$. Note thatr=0 stands for first level of decomposition.

$$JND(r,s,x,y) = 0.5 * qstep(r,s,x,y)$$

$$qstep(r,s,x,y)_{0.034} = q_0 \times freq(r,s) \times lumen(r,x,y) \times texture(r,x,y)$$

$$freq(r,s) = \begin{cases} \sqrt{2}, & if\ s = HH \\ 1, & otherwise \end{cases}$$

$$lumen(r,x,y) = 3 + \frac{1}{256}\sum_{i=1}^{2}\sum_{j=1}^{2} I^{r,LL}(i+x, j+y)$$

The texture is calculated from overall four bands of DWT and the value of texture is the sum of values of texture in three bands (LH, HL, and HH) and value of variance in LL band.

$$texture = TextureLH + TextureHL + TextureHH + varLL;$$

The value of JND from above information is calculated as:

$$HHT = frequency.* \; luminance.* \; (texture)^{0.034};$$

E. Watermark Embedding

*Step 1.*For a given N×N cover image, apply the discrete wavelet Transform.

*Step 2.*The decompose image by DWT gives four sub-bands LL, HL, LH and HH, choose HH sub-band.

*Step 3.*After that, apply the discrete cosine transform on the higher energy sub-band of image.

*Step 4.*Apply singular value decomposition on the DCT transformed higher energy sub-band of image in order to calculate singular values.

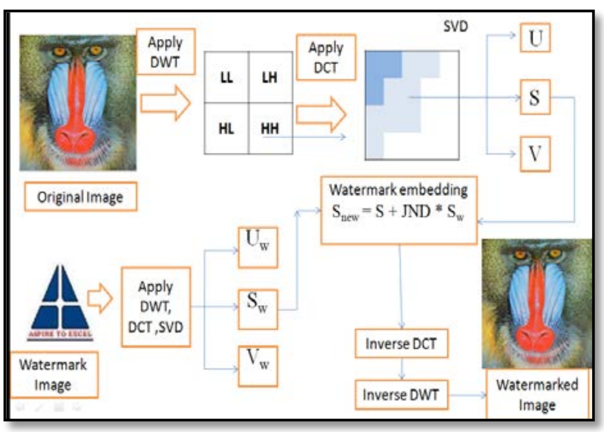

Figure2. Block Diagram for Watermark Embedding Algorithm

*Step 5.*Similar operation performed on the watermark. After calculating singular values of both the cover image and watermark say S1 and S2. We have to combine them using perceptual factor of JND as:

$$S = S_1 + f_{jnd}\, S_2$$

Here, f_{jnd} is the JND value calculated as per DWT.

*Step 6.*Then singular value S is again combined with the unitary matrix of cover image in order to restore it.

*Step 7.*Finally, inverse DCT and inverse DWT is performed to produce the watermarked image.

F. Watermark Extraction

*Step 1.*For a given N×N watermarked image, apply the discrete wavelet Transform.

*Step 2.*Discrete cosine transform is applied in the similar manner as earlier in order to transform the image spatial domain image into DCT domain.

*Step 3.*Finally, the watermark is extracted from the selected wavelet coefficients by applying the singular value decomposition on the watermarked image and restoring it with the help of same JND coefficients generated earlier.

*Step 4.*After extracting the final watermark, compares it with the original watermark, to find the any attacks happened in the original data.

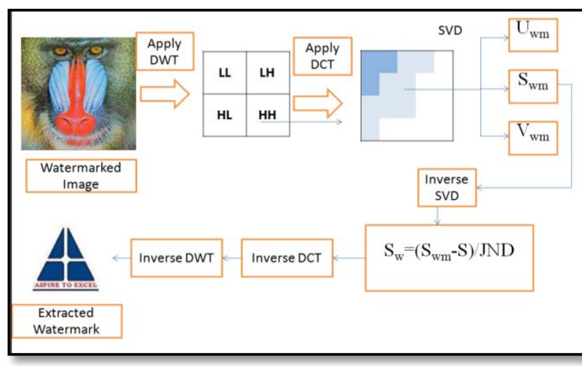

Figure3. Block Diagram for Watermark Extraction Algorithm.

IV. RESULTS & DISCUSSION

A. Performance criteria

In the evaluation of the performance of the watermarking scheme, for robustness validation this work use the mean square error (MSE) between the original and watermarked images, respectively, peak signal to noise ratio (PSNR), correlation factor between input and output watermarked image and Weighted peak signal to noise ratio WPSNR. The image pixels are assumed to be 8 bits to give a maximum pixel value of 255. To test the effectiveness of proposed algorithm for better invisibility, this work use PSNR and MSE between input cover media and watermarked media (after embedding watermark in original image).

B. Experimental results

The proposed DCT-DWT based watermark technique has been applied to several images, including the 512×512 sizes of Lena, Mandrill, and Barbara images. In these experiments, we have chosen a random sequence for creating the watermark matrices. The embedded watermarks cause invisibility distortion at levels that provide reliable detection.

The channel parameters like Peak signal to Noise ratio (PSNR), Weighted Peak signal to Noise ratio (WPSNR), Mean signal Error(MSE) have been calculated and applied to obtain Watermarked images from both the proposed approach and traditional DCT & DWT based approach as well as applied on cover image. The channel parameters have used to evaluate performance of both the systems. PSNR is the ratio between the maximum possible power of a signal and the power of corrupting noise that affects the fidelity of its representation. PSNR is generally expressed in terms of the logarithmic decibel (dB) scale.

$$PSNR = 10 \log_{10}\left(\frac{255^2}{E}\right)\ dB$$

Where E is Mean Square Error, $f\,(i,j)$ is pixel value of original image $f'(i,j)$ of watermarked image and its logarithmic unit is dB given by Formula:

$$E = \frac{1}{M \times N} \sum_{i=1}^{N} \sum_{j=1}^{M} [f(i,j) - f'(i,j)]^2$$

The weighted PSNR (WPSNR) has been defined as an extension of the traditional PSNR. It weights each of the term of PSNR by local activity factor (linked to the local variance).The PSNR metric does not take into account image properties such as flat and textured regions. The watermark is embedding into edges and into textured regions, so the PSNR is not enough to measure image quality in this case. Weighted PSNR is the solution of this problem. NVF identifies texture and edge regions and it characterizes the local image properties. This allows us to find out the optimal watermark location and strength for watermark embedding stage.

$$\mathrm{WPSNR} = 10(\mathrm{L}_{\max}^2)(\mathrm{MSE} \times \mathrm{NVF})^2$$

Where, $\mathrm{L}_{\max} = \frac{1}{(1+\theta\sigma x^2(\mathrm{I.J}))}\theta = \mathrm{D}\sigma x_{\max}^2$

Where, $\sigma x_{\max}^2$ is maximum local variance of a given image and $D \in [0,150]$ is a determined parameter.

Simulations are carried out in MATLAB R2013b (Version 8.2.0.703), graphical user interface is created for the simulation of proposed work on digital image watermarking processing including the embedding and extraction process.

Also, there was a need to analyse how attacks can modify the watermarked images and their corresponding detectors response. The primary purpose of the various attacks on the watermarked images is to know the survival, i.e., whether the watermark has survived or not. Survival of the watermark shows that it can be extracted as a replica of the original watermark. However, the extracted watermark was degraded due to channel noise while broadcasting and other intentional attacks. The watermarked image has been tampered with the built-in functions of MATLAB software suite. The attacks performed in this research work are as follows: joint photographic experts group (JPEG) compression, Image Adjustment, Rotation, Histogram Equalization Salt and pepper noise attack, Speckle noise, Gaussian noise attack, etc.

The primary goal of this experiment was to determine whether the proposed watermarking scheme improved the robustness without any loss in the quality of the image. Also, to increase the imperceptibility of watermark in cover image without degrading the robustness.

C. Input Database

The input database images taken for the experimental purpose are Lena, Mandrill, and Barbara along with the single watermark. All images are in bmp format (bitmap image file). Figure below shows the RGB image files for the three input cover images.

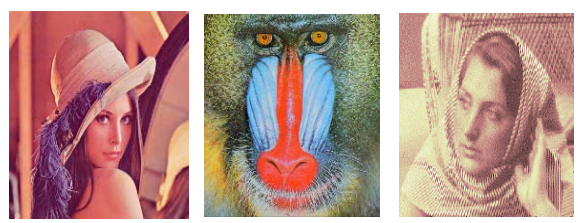

Figure 4.Input images considered during experiment (Lena, mandrill and Barbara), all are in RGB color space.

Figure 5.RGB to Gray conversion of input images. However the proposed system can work on RGB color space by

applying the watermarking process in individual page of a color multi-dimensional matrix.

Figure 6.Shows the RGB color space input watermark image.All the experiments (with all three cover images) are done with this watermark.

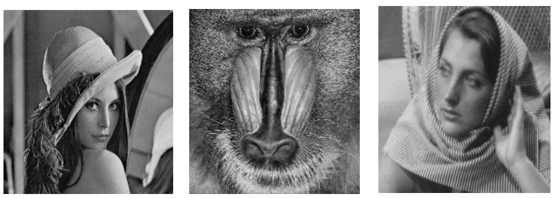

Figure 7.Shows the watermarked image after applying the proposed embedding process using traditional Haar wavelet in JND based hybrid DWT-DCT model. The efficiency of proposed system in terms of invisibility is shown in tables of next sections.

Table below shows the different type of wavelets using during the experiment, it is proved that, higher level wavelets proved to be better as compare to traditional wavelets used earlier by some authors, different type of wavelet filters are applied using MATLAB’s wavelet toolbox using function ‘wfilters’.

TABLE I: TYPES OF WAVELETS USED IN PROPOSED SYSTEM

S.No.	Type of wavelet
1	‘db1’ or Haar Wavelet
2	‘db2’ or Daubechies level two wavelets
3	‘db4’ or Daubechies level four wavelets
4	‘sym2’ or Symlets level two wavelets
5	'dmey' or Discrete Meyer wavelets
6	‘db45’ or Daubechies level 45 wavelets

D. Comparative Analysis

This section provide a comparison and validation of proposed methodology, in terms of PSNR and MSE in order to prove the proposed JND based Hybrid DWT-DCT approach is better as compare to traditional DWT-DCT based approach. Tables below in this section show the value of PSNR and MSE for the both methods in both the cases (test for robustness and test for invisibility). The wavelet used for comparison is traditional Haar wavelet (Sequence of rescaled "square-shaped" functions which together form a wavelet family or basis).

Figure 8.Shows the watermark image input in proposed system and extracted watermark after embedding process (figure taken while taking haar wavelet and channel without noise)

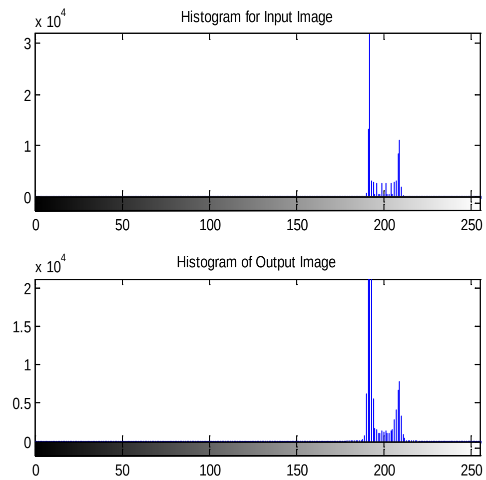

Figure 9. Shows the intensity level histogram of watermark image input in proposed system and extracted watermark after embedding process (this histogram is taken while taking haar wavelet and considering channel without noise)

TABLE II: EFFICIENCY OF PROPOSED SYSTEM IN TERMS OF PSNR, MSE, WPSNR FOR DIFFERENT WAVELET USED FOR LENA IMAGE (* shown for robustness comparison between input and output watermark and # shown for invisibility comparison between input cover image and watermarked image)

Parameter	Haar	Db4	Sym	Mayer	Db45
PSNR (*)	99.305	104.16	88.166	104.16	90.0261
MSE (*)	0.0076	0.0084	0.0099	0.0084	0.0064
WPSNR (*)	124.56	126.12	94.275	126.12	103.085

PSNR (#)	61.074	61.911	62.855	63.378	63.7871
MSE (#)	0.0507	0.0418	0.0336	0.0298	0.0271

TABLE III: EFFICIENCY OF PROPOSED SYSTEM IN TERMS OF PSNR, MSE, WPSNR, AND CORRELATION FOR DIFFERENT NOISE DISTORTION USED FOR LENA IMAGE (using Haar wavelet)

Parameter	Salt & pepper	Gaussian	Sharpened	Speckle	Rotation	Without
PSNR	51.2364	45.7369	68.2101	52.2922	76.1253	99.3059
MSE	0.4891	1.7353	0.0098	0.3835	0.0015	0.0076
WPSNR	77.1737	71.6507	94.7357	78.2528	101.394	124.565
CORR	0.9821	0.9397	0.9996	0.9858	0.9998	1

TABLE IV: COMPARISON OF PROPOSED SYSTEM WITH DWT-DCT BASED APPROACH IN TERMS OF PSNR AND MSE FOR THE CASE OF ROBUSTNESS (BY COMPARING INPUT AND OUTPUT WATERMARK)

Image Name	Proposed System		DWT-DCT	
	PSNR	MSE	PSNR	MSE
LENA	99.3059	0.0076	47.1694	1.2368
BARBARA	94.5347	0.0022	49.6264	1.2894
MANDRILL	91.9023	0.0041	47.9217	1.5697

TABLE V: COMPARISON OF PROPOSED SYSTEM WITH DWT-DCT BASED APPROACH IN TERMS OF PSNR AND MSE FOR THE CASE OF INVISIBILITY (BY COMPARING INPUT COVER IMAGE AND WATERMARKED IMAGE)

Image Name	Proposed System		DWT-DCT	
	PSNR	MSE	PSNR	MSE
LENA	61.0741	0.0507	34.7466	1.4286
BARBARA	61.0335	0.0512	40.5694	1.4951
MANDRILL	62.1072	0.0400	38.5029	2.4062

V. CONCLUSION& DISCUSSION

In the present globalization, the availability of the Internet and various image processing tools opens up to a greater degree, the possibility of downloading an image from the Internet, manipulating it without the permission of the rightful owner. For these reasons image authentication has become not only an active but also vital research area. Embedding watermarks in both signals and images can cause distortion in them. Hence, an effective watermarking scheme is always an imperative requirement.

Following conclusions can be drawn based on the work presented in this paper. As value of scaling factor increases, MAE between host image and watermark becomes significant thereby reducing imperceptibility. However, loss of perceptibility is less when watermark is embedded in high frequency components of host image. Since high frequency components of an image correspond to edges and borders of an image, embedding watermark causes distortion in images. But this distortion is affordable as compared to distortion in image caused by embedding watermark in HL or LH frequency components. Frequently, high frequency components are eliminated in image processing attacks, which results into loss of watermark information. However, such elimination is possible or can be of major concern in data compression. In watermarking, main emphasis is on protecting copyright information or content identification and not on data compression. Thus, it is acceptable to embed the watermark image in high frequency components rather than in low or medium frequency components.

The proposed JND based hybrid DCT-DWT technique provides better imperceptibility and higher robustness against attacks, as compared to traditional DWT and DCT based Hybrid scheme. Each watermark bit is embedded in various frequency bands and the information of the watermark bit is spread throughout large spatial regions. As a result, the watermarking scheme is robust to attacks in both frequency and time domains.

The experimental results show the proposed embedding technique can survive the image enhancement, cropping of an image and the JPEG lossy compression. However, improvements in their performance can still be obtained by viewing the image watermarking problem as an optimization problem. In this paper we applied JND model. By carefully using JND scaling multiple watermarking and repeatedly embedding to harden the robustness are also possible. This technique could applied on colour images and also be applied to the multi resolution image structures with some modification about the choice of middle frequency coefficients. In this proposed method the values of the PSNRs of the watermarked images are always greater than 40 dB and it can effectively resist common image processing attacks, especially by JPEG compression and different kind of noises (Gaussian noise, speckle noise, salt & pepper noise, Poisson noise etc.). In proposed work, there's also an option for selecting a wavelet from different type of wavelets, experiments proved that Symmlet and Mexican hat wavelets proved better as compare to traditional wavelets like Haar and daubechies. A very good balance between robustness and imperceptibility has been achieved using this scheme as observers can evaluate the quality of the watermarked image as well as the recovered watermark to be good. Experimentation using various sizes of watermarks and different images enables a better understanding of the scheme. WPSNR is used to evaluate the perceptual quality of the watermarked image effectively considering the effect of HVS.

VI. REFERENCES & ALLUSIONS

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