ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An UGC Approved Journal)

Website: www.ijareeie.com

Vol. 6, Issue 8, August 2017

Hybrid DWT, DCT, Contourlet Transform and SVD for Digital Image Watermarking

Venkateshwarlu Ananthaneni[1], Usha Rani Nelakuditi[2]

Research Scholar, Dept. of ECE, Vignan University, Guntur, A.P. India[1]

Professor & HOD, Dept. of ECE, Vignan University, Guntur, A.P., India[2]

ABSTRACT: In this paper, a hybrid watermarking system is proposed to obtain high security to the images with high PSNR. Using various transforms and their combinations the hybrid watermarking models are tested for different performance analysis factors. DWT, DCT, SVD and Contourlet transforms were used to analyze the performance of digital image watermarking for a Lena image along with a logo of 512×512 pixel size each. This experiment was conducted for different digital image attacks and tested for the quality of extracted output image from the embedded watermarking. The combination of all transformations delivered good results with highest PSNR with a good quality of output extraction. A summary of obtained results were tabularized for further research prospects and development.

KEYWORDS: Hybrid Watermarking, discrete wavelet transform (DWT), discrete cosine transform (DCT), singular value decomposition (SVD) and Contourlet transform (CT).

I. Introduction

Digital image watermarking has been a tool in the area of computer science to ensure the safety and authenticity as a proof of ownership by being an invisible signature within the image. This help authorized owners from the theft of images and random distribution of images on internet. The digital data (viz., images, audio, and video) will be inserted / embedded by using various transformation techniques to ensure the safe transmission of data from theft [1]. This data will be extracted at the receiving end without any error by using various image processing methods. Wide ranges of algorithms are in use for the digital watermarking, where the digital information is available in pieces of coefficients. However due to the nature of robust or semi-fragile nature the single watermarking is having limited and bounded applications. To overcome such issues hybrid watermarking is introduced and this method can combine both robust and semi-watermark methods so as to ensure an efficient watermarking method. To accomplish such a method to design hybrid watermarking various algorithms are used in the market. These algorithms included with powerful transformations with frequency domain watermarking techniques such as discrete wavelet transform (DWT), discrete cosine transform (DCT), discrete Fourier transform (DFT), discrete Hadamard transform (DHT), singular value decomposition (SVD) and Contourlet transform (CT) [2]. In some applications these transformations are used individually or multiples of two or more depending on the requirement of accuracy and efficiency of a particular applications.

A. Background

Since the evolution of digital watermarking in 1992 [3], many technical developments using algorithms, methodologies and techniques were introduced to protect the digital data out of the threat due to vast usage of internet for sharing information. In this section, latest information about watermarking techniques are discussed, hence earlier part of research aspects are ignored and some of the important landmarks are discussed in the area of digital watermarking.

First the watermarking of JPEG2000 images in compressed and encrypted format using a robust watermarking algorithm was proposed by Subramanyam *et al.* in the encrypted domain. Using this method the image can be retrieved decrypted domain [4]. However to enhance the robustness and to simplify the complexity Wang *et al.* proposed an informed image watermarking scheme by developing a hidden Markov model (HMM) to tackle the problem of unavailability at the receiving end [5]. Later a hardware implementation was proposed by Roy *et al.* in the area of digital watermarking system for inserting invisible, semi-fragile information with compressed video streams by using pipe line structures and parallelism which allowed high performance [6]. The total implementation was done by using the field programmable gate array (FPGA) and such method can withstand for various potential attacks, such as cropping, cover-up and segment removals in the real-time.

Optical watermarking technology using orthogonal transforms such as DCT or Walsh-Hadamard transform (WHT) for producing watermark images. Using this method each pixel block was embedded with 1-b binary information. Ishikawa *et al.* proposed an optimal condition for a robust optical watermarking with varying pixel boxes [7].

The watermarking for colour images demands a careful attention to achieve tamper proofing and recovery with high quality. Liu suggested an efficient method of self- embedding watermarking scheme for authentication of color images using dual option parity check method and morphological operations [8]. Later, Liu proposed the same scheme by using bi-level moment preserving technique to recover the watermarked image with high quality [9]. The author also proposed two-stage dual parity-check and also used various morphological operations to ensure the validity of image blocks. Similar attempt was made by Khalili and Asatryan to enhance security, robustness and imperceptible CDMA image watermarking by using discrete wavelet transformation in eight color spaces [10]. This method proved to be more imperceptible as compared to JPEG compression.

Later the applications of optimized 3D watermarking proposed by Bors and Luo ensured the watermarking of object surface and also the actual vertex displacement [11]. This method helps to achieve high robustness and common mesh attacks are avoided using this method. However, by using accurate Zernike moments (ZMs) Singh and Ranade proposed another high-capacity watermarking method which is also seem to be image adaptive [12]. To reduce the overall ZMs the authors introduced conditional quantization technique which allowed improving visual imperceptibility and robustness of images against different attacks.

Bianchi and Piva highlighted various advantages and open issues of watermarking in the area of signal processing and explained various watermarking models and various commitment schemes which are additively homomorphic with some specific importance [13]. A method of using biometric data for watermarking was introduced by Majumder *et al.* using iris to enhance the security for digital images [14]. The algorithm proposed in this method tested with popular attacks towards false recognition and rejection of other subject matters.

Digital image watermarking based on features using interest point extraction and extended pilot signals are proposed by Su *et al.* to resist geometrical transformations. In this method, at the time of detection the synchronization will be obtained by adjusting related affine parameters of grids on original image [15]. However, to ensure a secured watermarking for grayscale images Mathon *et al.* proposed to use the elements of transportation theory so as to reduce global distortion by applying transportation natural watermarking (TNW) [16]. This experiment allowed enhancing the security properties in terms of key security and subspace security. To provide a solution for the security problems at the time of digital image mapping Jianguo *et al.* proposed a lossless digital watermarking scheme with zero-perturbation for the contents and graphics of digital images [17]. This in turn provided lower complexity and much better in performance as compared to the classical algorithms that are based on space or frequency domains. Later a novel reversible fragile watermarking algorithm was proposed by Chan *et al.* towards digital hologram authentication, in which the marked hologram will be stored with finite resolution levels in spatial domain [18]. This Hadamard transform based watermarking system can be used for both embedding and extraction with improved hiding capacity for different resolution levels. To detect and recover the tampered area from the received image is proposed by Sarreshtedari and Akhaee using source-channel coding approach [19]. The proposed method by these authors used channel encoder for protecting the original image and used channel erasure decoder for retrieving the original image. Later Sarreshtedari *et al.* introduced a new watermarking method by generating a digital self-embedding speech signals which are having he provision of self-recovery features [20]. This experiment delivered an efficient method to recover the speech quality for high tampering rates of digital speech with reduced loss of original speech signals. For color images in sparse domain Sadreazami *et al.* proposed a multiplicative watermarking detector which is based on multivariate Cauchy distribution [21]. An improved detection rate with robustness against the various attacks was observed effectively.

The watermarking using partial pivoting lower and upper triangular (PPLU) was proposed by Muhammad and Bibi used a valid key matrix to ensure the authentication for the righteous person, i.e. the owner of the image [22]. This method proposed an algorithm with highly reliable and imperceptibility for the embedded image and efficiency. Similar

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An UGC Approved Journal)

Website: www.ijareeie.com

Vol. 6, Issue 8, August 2017

method but in a different way Andalibi and Chandler used adaptive logo texturization for image watermarking [23] with a challenge of ensuring the watermark imperceptible within the original image and also need to maintain the robustness to various attacks.

So far various watermarking techniques proposed by different authors were seen along with their role and influence on various security issues. In the next section, a brief introduction to each transformation technique will be given for a better understanding.

II. WAVELET TRANSFORMATIONS

The role of wavelet analysis to solve various problems in different disciplines with systematic representations and multi-scale structures makes it special in the area of digital image watermarking. The theories laid down by Fourier for frequency analysis are important and proved to be influential in various transformation analyses [24]. Efficient representation of wide range of functions is much larger than square-integrable functions in wavelet analysis. On the other hand different algorithms used for computations in wavelet analysis are more accurate and allows reducing noise with optimum hardware resources [24].

In general a wavelet is denoted by $\psi_\lambda(x)$ and here x belongs to spatial domain $\boldsymbol{X}$, ψ_λ belongs to Class $\boldsymbol{F}$ of functions and λ belongs to an index set of Λ.

For a given $\boldsymbol{X}$ (real line), $\boldsymbol{F}$ as $L^2(R)$, Λ as Z^2 with
$\lambda = (j, l)$ and $\psi_\lambda(x) = 2^{-j/2}\psi_\lambda(2^j x - l)$; here ψ is considered to be the wavelet basis and is given by
$\psi = (\psi_\lambda / \lambda \in \Lambda)$ [24].

A. Discrete Wavelet Transform (DWT)

This was first introduced by Alfrisd Haar, in which the wavelet transforms are considered as finite-energy signals out of a wavelet-based expansion or decomposition. In DWT, orthogonality of basis set of the functions is used to expand the key points [25], which helps in maintaining the economy towards representing the signals with the help of DWT coefficients along with the possible perfect signal reconstruction. A DWT based problem involves two functions: scaling function and wavelet function. The computation of DWT includes convolution followed by the down-sampling [26]. It can be used as an efficient digital signal processing (DSP) tool for the development of an image and as a video compression algorithm [27].

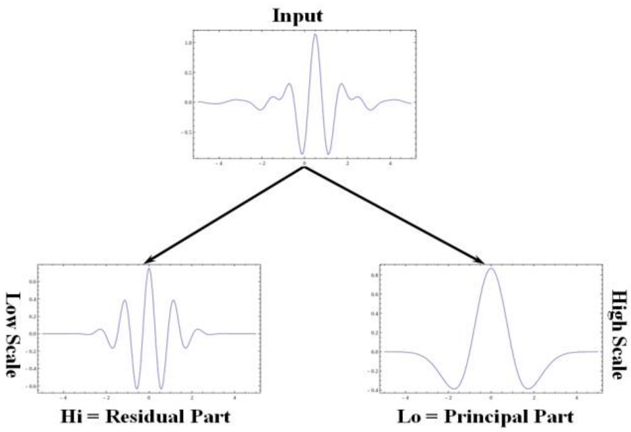


Fig. 1. The representation of a fundamental cell of multi-resolution analysis (MRA): Representation of a mother wavelet and their scaled versions.

The basic set of wavelet generated as shown in Fig. 1. is given by

$$\psi_{a,b}(t) = \frac{1}{\sqrt{a}}\psi\left(\frac{t-b}{a}\right); a, b \in \text{ and } \quad a > \quad \ldots \quad (1)$$

here is representing the set of real numbers, reflecting the scale of a basis function, which is inverse of frequency, represents the translation (i.e., shifting) along $x - \alpha$ in time domain and used for normalization [24, 25, 26].

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An UGC Approved Journal)

Website: www.ijareeie.com

Vol. 6, Issue 8, August 2017

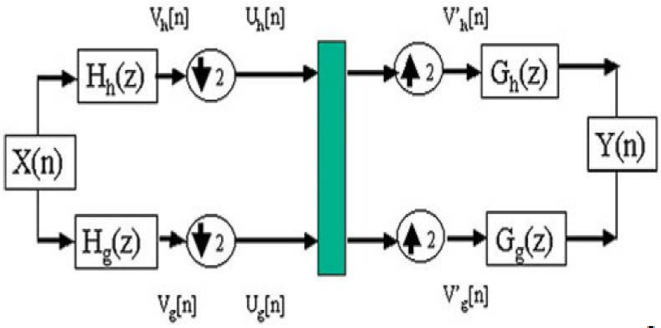


Fig. 2. Generic Form of 2-DWT, i.e. two-channel filter bank with analysis filter bank $[H_h(z)$ and $H_g($ and synthesis filter bank $[G_h(z)$ and $G_g($

The other important aspect to be considered here is to have the mother wavelet with finite energy need to satisfy the following conditions:

$$\int_{-\infty}^{\infty} |\psi(t)|^2 \, dt < \quad \ldots \quad (2)$$

The DWT transforms discrete time signal to a discrete wavelet representation.

B. Discrete Cosine Transform (DCT)

This transform represent overall input data points with different frequencies and magnitudes as a sum of cosine functions. Two types of DCTs are available: one dimensional (1-D) and two dimensional (2-D) DCTs [28]. However, 2-D DCTs are preferred over 1-D DCTs due to the representation of an image will be in 2-D format. But a 2-D DCT is in general an extension of 1-D DCT, which is given by

$$C(u,v) = \alpha(u)\alpha(v)\sum_{x=0}^{N-1}\sum_{y=0}^{N-1} f(x,y)\cos\left[\frac{\pi(2x+1)u}{2N}\right]\cos\left[\frac{\pi(2y+1}{2N}\right] \quad (3)$$

for $u,v = 0,1,2,3,\ldots N$ - and $\alpha(u)\alpha($ are defined.

The inverse transform is defined as

$$f(x,y) = \sum_{u=0}^{N-1}\sum_{v=0}^{N-1} \alpha(u)\alpha(v)C(u,v)\cos\left[\frac{\pi(2x+1)u}{2N}\right]\cos\left[\frac{\pi(2y+1}{2N}\right] \quad (4)$$

for $x,y = 0,1,2,3,\ldots N$ -

A 2-D basis function will be generated by multiplying horizontal 1-D basis function with vertical oriented set of similar functions. In the case of 2-D DCT, the basis functions exhibit a progressive increase in frequency in both the directions.

C. Singular Value Decomposition

SVD for a real matrix will be described as shown in Eq. 5 and can be decomposed into 3 matrices, i.e. $A = U\,D\,.$

$$A = \begin{bmatrix} u_1 & u_2 & \cdots & \cdots & u_N \end{bmatrix} \begin{bmatrix} \lambda_1 & & & \\ & \ddots & & \\ & & \ddots & \\ & & & \lambda_R \\ & & & & 0 \end{bmatrix} \begin{bmatrix} v_1 \\ v_2 \\ \vdots \\ \vdots \\ v_N \end{bmatrix} \quad \ldots \quad (5)$$

Here and are orthogonal matrices and diagonal entries of are called singular values of . The columns of are called right singular vectors of and columns of are right singular vectors of [29]. The singular value represents the energy intensity of corresponding Eigen image.

Such decomposition is known to be singular value decomposition (SVD) of and is expressed as follows.

$$A = \lambda_1 U_1 V_1^T + \lambda_2 U_2 V_2^T + \cdots + \lambda_r U_r \quad \ldots \quad (6)$$

here is the rank of matrix .

The singular values here specify the luminance of image layer and corresponding pair of singular vectors in general represent the geometry of the image. In this method, the complete cover image will be applied with SVD and then

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An UGC Approved Journal)

Website: www.ijareeie.com

Vol. 6, Issue 8, August 2017

allow to modify singular values to embed with watermark data. In this, method an image will be viewed as non-negative real matrix. The important property of SVD is that the modified singular values will change to a minimum extent for most of the attacks [30].

D. Contourlet Transform

It is a geometrical transform which captures edge information of the image efficiently in all directions to overcome deficiencies of previous transform by introducing multiscale and directional representation of different images. This transform consist of Laplacian Pyramid (LP) and directional filter bank (DFB). The first one, LP, is constructed from pair of filters called analysis and synthesis. LP decomposition generates low frequency subband images at each level and an image will be decomposed into an octave radial-like frequency band as shown in Fig. 3, which allows capturing all the discontinuities and differences between original and predicted image, i.e. resulting to a band pass image [31].

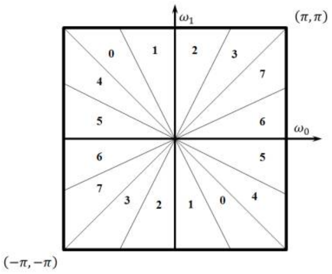


Fig. 3. Frequency partitioning in DFB for $k =$
i.e. 2^k = subband

For an image $X(i$ in the first pyramidal stage it will be down sampled and generate low pass image labeled with $X_{L_0}(i$ and prediction error is considered as de-correlated bandpass image $X_{H_0}(i$ as given below:

$$X_{H_0}(i,j) = X(i,j) - X^*_{L_0}(i \quad \ldots \quad (7)$$

$X_{L_0}(i$ obtained via decomposition is processed by DFB in the next stage so as to form PDFB of CT [32].

III. PROPOSED METHOD AND EVALUATION PROCESS

The implementation of a digital watermarking involve following three steps:

1) Watermark embedding process

In the presented work a logo image is embedded into a Lena image of 512×512 pixel size (see Fig. 4) with standard watermarking embedding process. In this process the priority is given to embed the edges of image to be watermarked since edges will have important information at the finite frequency scale. It is also noted that the large absolute value gives a close agreement with edge information of the image. The selection of watermark coefficients are based on the criteria of edge information and also based on predefined threshold, which in general have larger values [33].

2) Watermark extraction process

The extraction of information from the watermark will be taking place in the absence of original image and aims to obtain estimated original watermark from distorted version of watermarked image. This process is having an inverse procedure that of an embedding process. The ability to spread watermark for the entire image is an advantage of watermarking so that parts of watermark will be available even when the image is cropped. Such property will allow detecting the original watermark even when the image is cropped, scaled or rotated. The altered curvelet coefficients and the binarized specific threshold values are used to detect the logos [33].

3) Performance evaluation

The basic idea of evaluating the performance is to check and compare the total amount of distortion introduced for the input image using the watermarking insertion algorithm. The performance evaluation process test the quality of image at the output of decoder with the following measuring parameters:

- Mean Square Error (MSE)

According to Santhi, MSE of an estimator "…*is one of many ways to quantify the amount by which an estimator differs from the true value of the quantity being estimated*" (pp.64) [34]. However it is also called as a loss function or squared error loss and is given by:

 DOI:10.15662/IJAREEIE.2017.0608018

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An UGC Approved Journal)

Website: www.ijareeie.com

Vol. 6, Issue 8, August 2017

$$MSE = \frac{1}{MN}\sum_{x=1}^{M}\sum_{y=1}^{N}[I(x,y) - I'(x,y)]^2 \quad \ldots \quad (8)$$

here, $I(x,y)$ is original image; $I'(x,y)$ is decomposed image (approximation version); M and N are dimensions of images.

- Peak Signal to Noise Ration (PSNR)

PSNR represents the overall distortion caused to the original image due to the process of watermarking and depends on MSE and this factor evaluates imperceptibility of watermarking [35]. Signal to noise ration or PSNR in general expressed in logarithmic decibels due to wide dynamic range of signals that are used. In a logical approach higher the value of SNR or PSNR is better for a good watermarking extraction.

$$SNR = 10\log_{10}\left\{\frac{\sum_{x=1}^{M}\sum_{y=1}^{N}[I(x,y)]^2}{\sum_{x=1}^{M}\sum_{y=1}^{N}[I(x,y)-I'(x,y)]^2}\right\} \quad \ldots \quad (9)$$

and

$$PSNR = 20\log_{10}\left(\frac{255}{\sqrt{MSE}}\right) \quad \ldots \quad (10)$$

- Normalized Cross Correlation (NCC)

It is used to measure the correlation between watermarked image and original image [36], and is given by:

$$NCC = \frac{\sum_{x=1}^{M}\sum_{y=1}^{N}[I(x,y)-\overline{I(x,y)}][I'(x,y)-\overline{I'(x,y)}]}{\sqrt{\sum_{x=1}^{M}\sum_{y=1}^{N}[I(x,y)-\overline{I(x,y)}]^2\sum_{x=1}^{M}\sum_{y=1}^{N}[I'(x,y)-\overline{I'(x,y)}]^2}} \quad \ldots \quad (11)$$

here, $I(x,y)$is original image; $\overline{I(x,y)}$ is mean of original image; $I'(x,y)$ is watermarked image; $\overline{I'(x,y)}$ is mean of watermarked image with a range of 0 to 1.

- Similarity

This property finds the range of similarity between original and extracted logos and is given by:

$$Similarity = \frac{\sum_{x=1}^{M}\sum_{y=1}^{N} W(x,y)\times W'(x,y)}{\sum_{x=1}^{M}\sum_{y=1}^{N}[W'(x,y)]^2} \quad \ldots \quad (12)$$

where, $W(x,y)$ represents original logo image and $W'(x,y)$ represents extracted logo image with values between 0 to 1.

IV. IMPLEMENTATION OF WATERMARKING

To test and simulate the proposed approach, a Lena image with 512×512 pixel size was considered. The image was transformed through various transforms via wrapping and randomly generated a watermark with M= 262144 length. Each parameter is set to a scale of [4,5] with strength parameter α = 0.7. On the other hand, a logo image size of 512×512 pixels with written letter of J N T U of size 170×170 is used as a watermark image. This image is embedded with the edge of Lena image. At the edges, it is found to have high frequency components as compared to other locations of the watermarked image as shown in Fig. 4.

Fig. 4. The original image used with the watermark for the present experiment and analysis

Now the common signal processing procedures such as noise addition, low-pass filtering, median filtering and high-pass filters are applied onto the watermarked image to evaluate the performance of the signals as shown in Fig.5.

On the other hand, in this experiment geometrical attack such as cropping is used for the analysis of the watermarked image. In addition, further experiments were carried out to evaluate the robustness against more commonly used image processing attacks such as cropping, adding noise, lowpass filter, highpass filter, DCT compression and JPEG2000 compression as shown in Fig. 6.

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An UGC Approved Journal)

Website: www.ijareeie.com

Vol. 6, Issue 8, August 2017

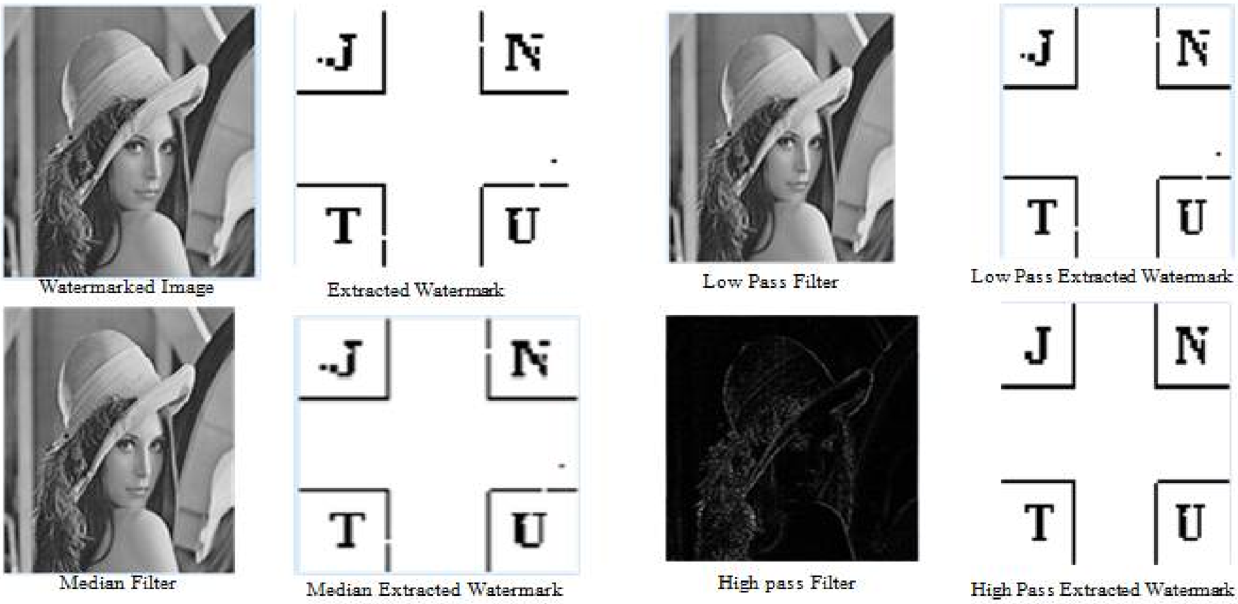


Fig. 5. The original images applied with filters along with their watermarked images

The proposed approach of hybrid watermarking to use the combination of different transforms in watermarking the digital images shown better results and PSNR seems to be high as compared to other methods as shown in Table I. Normalized cross correlation and similarity based methods are used to evaluate the effectiveness of the proposed method. The preliminary results show that the method is robust against some important image processing attacks.

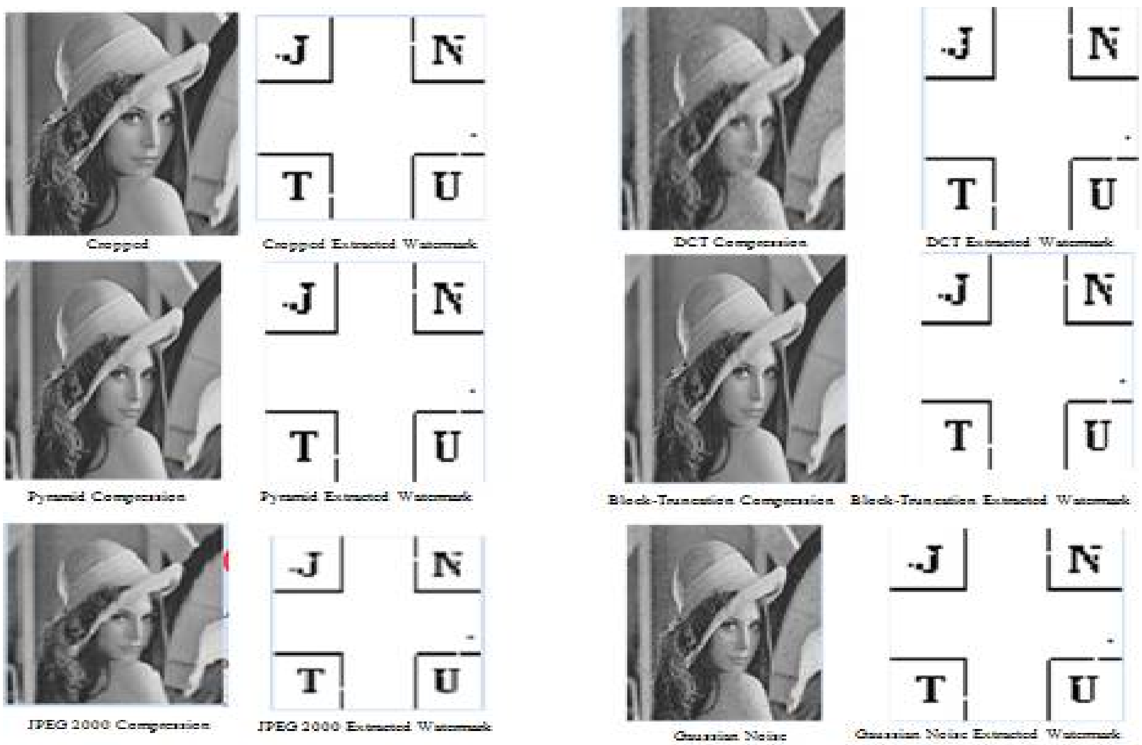


Fig. 5. The original images applied with filters along with their watermarked images

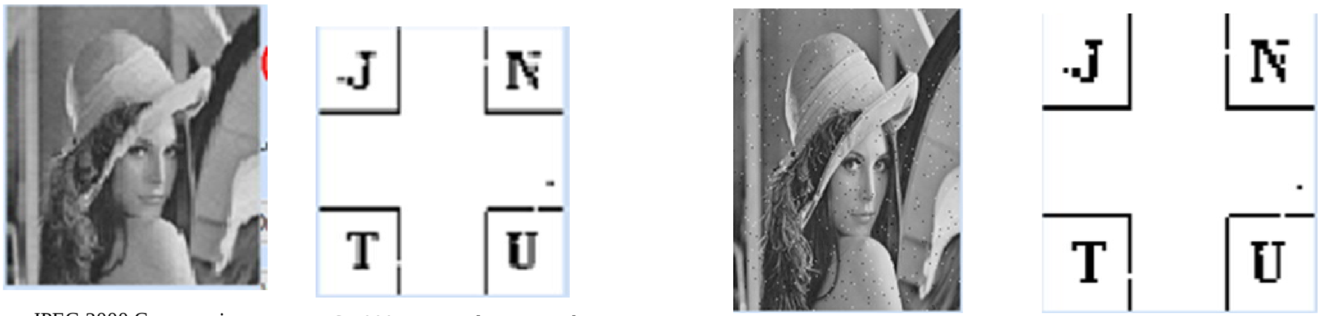
ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An UGC Approved Journal)

Website: www.ijareeie.com

Vol. 6, Issue 8, August 2017



JPEG 2000 Compression JPEG 2000 Extracted Watermark Gaussian Noise Gaussian Noise Extracted Watermark

Fig. 6. Impact of different image processing attacks on watermarking

The overall comparison and simulation results for different hybrid water marking approaches such as DWT-DCT-SVD *vs* CT-DCT- SVD *vs* DWT-CT-DCT-SVD are shown in Table I. PSNR found to be better as compared to other two methods as per the recommendations in literature review. A slight variation is found in the case of DCT compression for the last two hybrid models in this research but for the first case (i.e. DWT-DCT-SVD) it is less.

TABLE I Performance evaluation of Simulation Results of Hybrid Digital Image Watermarking using DWT-DCT-SVD *vs* CT-DCT- SVD *vs* DWT-CT-DCT-SVD

Types of Transform(s)	Single/Hybrid	HYBRID DWT-DCT-SVD				HYBRID CT-DCT-SVD				HYBRID DWT-CT-DCT-SVD			
Image after/ before attacks	Dependable Parameters	Similarity	NCC	MSE	PSNR[dB]	Similarity	NCC	MSE	PSNR[dB]	Similarity	NCC	MSE	PSNR[dB]
Watermarked Image	Strength Parameter (∝)=0.1	0.99513	0.99919	6.8247	39.79	0.99804	0.99998	0.11146	57.6596	0.99918	1	0.017012	65.8233
Low-Pass Filtering	3*3 Mask filter	0.81384	0.7496	27.634	33.7164	0.81549	0.97564	25.4035	34.0819	0.88495	0.9756	25.405	34.0816
Median Filtering	3*3 Mask filter	0.98557	0.99864	4.3349	41.761	0.98815	0.99948	1.2135	47.2905	0.99399	0.99984	0.36528	52.5046
High-Pass Filtering	3*3 Mask filter	0.030443	0.2178	254.5896	624.0724	0.029986	0.21908	254.5985	24.0722	0.041356	0.21949	254.5879	24.0724
Pyramid Compression	64*64 size	0.83958	0.97359	26.8899	33.8349	0.84008	0.97217	26.4633	33.9044	0.93654	0.99011	14.0726	36.6471
DCT Compression	64*64 size	0.78182	0.96645	37.2406	32.4206	0.78293	0.96491	36.6369	32.4916	0.87016	0.96489	36.6433	32.4909
Block Truncation Compression	64*64 size	1	1	0	∞	1	1	0	∞	1	1	0	∞
JPEG2000 Compression	64*64 size	0.86523	0.98824	20.6965	34.9718	0.86466	0.98757	20.44448	35.025	0.91584	0.98759	20.4092	35.0325
Cropping	64*64 size	0.539	0.35439	100.1907	28.1225	0.55819	0.42361	96.874	28.2687	0.7021	0.4316	93.3479	28.4298
Gaussian Noise	Variance=0.01	0.71412	0.9618	95.155	41.0085	0.71705	0.96046	2.02	45.0773	0.69345	0.9606	1.6647	45.9174

It is also seen that the Gaussian noise for the proposed hybrid watermarking model is very high as compared to first two transform methods (See Table II and Fig7). The value of PSNR is very High (45.9174) as a result of the combining all transform methods in this proposed hybrid watermarking model.

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An UGC Approved Journal)

Website: www.ijareeie.com

Vol. 6, Issue 8, August 2017

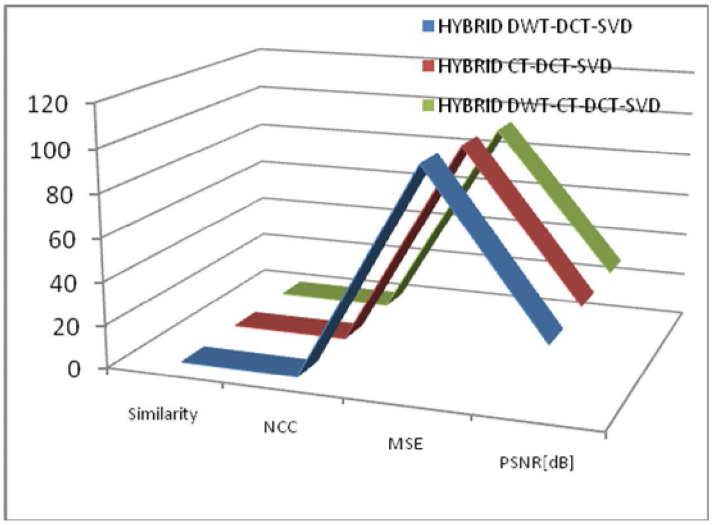


Fig. 7. Comparison of Gaussian Noise for different Hybrid Watermarking models

TABLE II Gaussian Noise of Hybrid Digital Image Watermarking using DWT-DCT-SVD *vs* CT-DCT- SVD *vs* DWT-CT-DCT-SVD

Types of Single/ Hybrid Transform(s)	Similarity	NCC	MSE	**PSNR[dB]**
HYBRID DWT-DCT-SVD	0.71412	0.9618	95.155	**41.0085**
HYBRID CT-DCT-SVD	0.71705	0.96046	2.02	**45.0773**
HYBRID DWT-CT-DCT-SVD	0.69345	0.9606	1.6647	**45.9174**

V. CONCLUSIONS

The simulation results for this research obtained high quality of watermarked image with high PSNR is obtained by embedding the watermark with high level decomposition. It is also seen that the increase in density of variance of Gaussian noise leads to an increase in the amount of noise induced which in turn affected the quality of image and hence need to modify the watermark embedded coefficient of the original image. However, with the increase in density or variance of the noise, leads to a decrease in PSNR and robustness of watermark seemed to be affected in spite of huge noise addition. Even in such scenarios the recovered watermark is still recognizable.

From the obtained results it is seen that the watermarking algorithm still sustains the cropping attacks and highly recoverable even for the cropping block sizes of 256×256. Apart from these the image passing through different attacks such as geometric, adding noise, filtering, etc. resulted to extract a perfect logo as expected. The proposed embedding algorithm proved to be robust and secure as the extracted logo location is not known. The image after watermarking is subjected to the low pass filtering and high pass filtering to remove the detailed coefficients. High pass filter removes the low frequency coefficients. Low pass filter is used to reduce the high frequency components. The

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An UGC Approved Journal)

Website: www.ijareeie.com

Vol. 6, Issue 8, August 2017

watermarking algorithm sustains the compression attack; the watermark is highly recoverable even for the compression block size of $M \times$. Further the experiments are carried out to evaluate the robustness against more commonly used image processing attacks such as JPEG2000 compression and DCT compression.

VI. ACKNOWLEDGMENT

The authors gratefully acknowledge the management of Vignan University for their support and facilities provided to conduct this research.

REFERENCES

[1] S. Jayaraman, S. Esakkirajan, and T. Veerakumar. "Digital Image Processing TMH Publication." *Year of Publication* (2009).
[2] D. Kumar and V. Kumar. "Improving the performance of color image watermarking using contourlet transform." *Advances in Computer Science and Information Technology* (2011): 256-264.
[3] A.Z. Tirkel, G. A. Rankin, R. M. Van Schyndel, W. J. Ho, N. R. A. Mee, and C. F. Osborne. "Electronic watermark." *Digital Image Computing, Technology and Applications (DICTA'93)* (1993): 666-673.
[4] A.V. Subramanyam, S. Emmanuel and M. S. Kankanhalli. "Robust watermarking of compressed and encrypted JPEG2000 images." *IEEE Transactions on Multimedia* 14.3 (2012): 703-716.
[5] C. Wang, J. Ni and J. Huang. "An informed watermarking scheme using hidden Markov model in the wavelet domain." *IEEE Transactions on Information Forensics and Security* 7.3 (2012): 853-867.
[6] S. D. Roy, X. Li, Y. Shoshan, A. Fish and O. Yadid-Pecht. "Hardware implementation of a digital watermarking system for video authentication." *IEEE transactions on circuits and systems for video technology* 23, no. 2 (2013): 289-301.
[7] Y. Ishikawa, K. Uehira and K. Yanaka. "Optimization of size of pixel blocks for orthogonal transform in optical watermarking technique." *Journal of Display Technology* 8, no. 9 (2012): 505-510.
[8] K.C. Liu. "Colour image watermarking for tamper proofing and pattern-based recovery." *IET image processing* 6.5 (2012): 445-454.
[9] K.C. Liu. "Self-embedding watermarking scheme for colour images by bi-level moment-preserving technique." *IET image Processing* 8.6 (2014): 363-372.
[10] M. Khalili and D. Asatryan. "Colour spaces effects on improved discrete wavelet transform-based digital image watermarking using Arnold transform map." *IET Signal Processing* 7.3 (2013): 177-187.
[11] A.G. Bors and M. Luo. "Optimized 3D watermarking for minimal surface distortion." *IEEE Transactions on Image Processing* 22.5 (2013): 1822-1835.
[12] C. Singh and S. K. Ranade. "Image adaptive and high-capacity watermarking system using accurate Zernike moments." *IET Image Processing* 8.7 (2014): 373-382.
[13] T. Bianchi and A. Piva. "Secure watermarking for multimedia content protection: A review of its benefits and open issues." *IEEE signal processing magazine* 30.2 (2013): 87-96.
[14] S. Majumder, K. J. Devi and S. K. Sarkar. "Singular value decomposition and wavelet-based iris biometric watermarking." *IET biometrics* 2.1 (2013): 21-27.
[15] P.C. Su, Y.C. Chang and C.Y. Wu. "Geometrically resilient digital image watermarking by using interest point extraction and extended pilot signals." *IEEE Transactions on Information Forensics and Security* 8.12 (2013): 1897-1908.
[16] B. Mathon, F. Cayre, P. Bas and B. Macq. "Optimal transport for secure spread-spectrum watermarking of still images." *IEEE Transactions on Image Processing* 23, no. 4 (2014): 1694-1705.
[17] S. Jianguo, Z. Chonghui, and G. Di. "Lossless digital watermarking scheme for image maps." *China Communications* 11.8 (2014): 125-130.
[18] H.T. Chan, W. J. Hwang and C. J. Cheng. "Digital hologram authentication using a hadamard-based reversible fragile watermarking algorithm." *Journal of Display Technology* 11.2 (2015): 193-203.
[19] S. Sarreshtedari and M. A. Akhaee. "A source-channel coding approach to digital image protection and self-recovery." *IEEE Transactions on Image Processing* 24.7 (2015): 2266-2277.
[20] S. Sarreshtedari, M. A. Akhaee and A. Abbasfar. "A watermarking method for digital speech self-recovery." *IEEE/ACM Transactions on Audio, Speech and Language Processing (TASLP)* 23.11 (2015): 1917-1925.
[21] H. Sadreazami, M. O. Ahmad, and M. S. Swamy. "A robust multiplicative watermark detector for color images in sparse domain." *IEEE Transactions on Circuits and Systems II: Express Briefs* 62.12 (2015): 1159-1163.
[22] N. Muhammad and N. Bibi. "Digital image watermarking using partial pivoting lower and upper triangular decomposition into the wavelet domain." *IET Image Processing* 9.9 (2015): 795-803.
[23] M. Andalibi and D. M. Chandler. "Digital image watermarking via adaptive logo texturization." *IEEE Transactions on Image Processing* 24.12 (2015): 5060-5073.
[24] S. K. Shukla and A. K. Tiwari. *Efficient algorithms for discrete wavelet transform: with applications to denoising and fuzzy inference systems*. Springer Science & Business Media, 2013.
[25] S. M. Alessio. "Discrete Wavelet Transform (DWT)." *Digital Signal Processing and Spectral Analysis for Scientists*. Springer International Publishing, 2016. 645-714.
[26] D. Sundararajan. *Discrete wavelet transform: a signal processing approach*. John Wiley & Sons, 2016.
[27] T. Acharya and P. S. Tsai. *JPEG2000 standard for image compression: concepts, algorithms and VLSI architectures*. John Wiley & Sons, 2005.
[28] V. Britanak, P. C. Yip and R. R. Kamisetty. *Discrete cosine and sine transforms: general properties, fast algorithms and integer approximations*. Academic Press, 2010.

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An UGC Approved Journal)

Website: www.ijareeie.com

Vol. 6, Issue 8, August 2017

[29] Z. Li, K. H. Yap and B. Y. Lei. "A new blind robust image watermarking scheme in SVD-DCT composite domain." *Image Processing (ICIP), 2011 18th IEEE International Conference on*. IEEE, 2011.
[30] D. Singh, N. Choudhary and M. Agrawal. "Scrambled hybrid wavelet-singular domain digital image watermarking." *Software Engineering (CONSEG), 2012 CSI Sixth International Conference on*. IEEE, 2012.
[31] M. N. Do and M. Vetterli. "The contourlet transform: an efficient directional multiresolution image representation." *IEEE Transactions on image processing* 14.12 (2005): 2091-2106.
[32] S. Majumder, M. Saikia, T. S. Das and S. K. Sarkar. "Hybrid image watermarking scheme using SVD and PDFB based contourlet transform." In *Computer and Communication Technology (ICCCT), 2011 2nd International Conference on*, pp. 130-134. IEEE, 2011.
[33] T. Sobh, K. Elleithy, A. Mahmood and M. Karim, eds. *Innovative algorithms and techniques in automation, industrial electronics and telecommunications*. Springer Science & Business Media, 2007.
[34] V. Santhi. ed. *Emerging Technologies in Intelligent Applications for Image and Video Processing*. IGI Global, 2016.
[35] N. K. Sarva and U. N. Rao. "Robust & Blind Video Watermarking Algorithm Using SVD Transform." *International Journal of Engineering Research and Technology*. Vol. 3. No. 5 (May-2014). IJERT, 2014.
[36] E. S. Corchado, V. Snasel, J. Sedano, A. E. Hassanien, J. L. Calvo and D. Slezak, eds. *Soft Computing Models in Industrial and Environmental Applications, 6th International Conference SOCO 2011*. Vol. 87. Springer Science & Business Media, 2011.

BIOGRAPHY

Venkateswarlu Ananthaneni (M'1981, M'36) was born in Hyderabad on Feb 12, 1981. He graduated from JNTU Hyderabad.Presently he is working in Adams Engineering College as an Associate Professor with a teaching experience of about ten years.Mr. Ananthaneni is a Research scholar and presently pursuing Ph.D from Vignan's University, Guntur, Andhra Pradesh, India. He received M.Tech Degree in Digital Systems and Computer Electronics from JNT University, Ananathapur. He had one International Journal, 2 Publications in International Conferences and also I had Professional Bodies member like, Member of IEEE, Member of ISTE.

Usha Rani Nelakuditi (F'1975, F'42) was born in Warangal She graduated from JNTU Anantapur, AP. Dr. Nelakuditi has more than 20 years of experience at various levels of Academic and Administrative Positions. She is presently working as Professor and Head, Department of ECE, Vignan University, Guntur, Andhra Pradesh, India. Research areas are Image/Video processing and video communications. She had more than 45 Publications in various reputed International/National Journals and Conferences. She had Professional Bodies member like Fellow of IETE, Member of IEEE, and Member of ISTE.